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<b>14. ABSTRACT</b> This TOP provides basic information to facilitate test planning, conducting, and reporting, and to achieve standardized chemical, biological, and radiological (CBR) contamination survivability testing of small items of mission-essential (ME) Army materiel. Small items, for example, include personal gear, small arms, radios, optical devices, small electrical generators, and small packages of materiel. This TOP describes typical facilities, equipment, and procedures used to contaminate small items of equipment, sample for contamination density, decontaminate, sample for residual contamination, determine ME function degradation resulting from contamination/decontamination procedures, and to assess the item operator/CBR protective gear compatibility. This TOP is to be used primarily for the testing of small items of equipment that are decontaminated by the individual Warfighter or by two-person or three-person teams operating portable and handheld decontaminating devices.					
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U.S. ARMY TEST AND EVALUATION COMMAND  
TEST OPERATIONS PROCEDURE

\*Test Operations Procedure 08-2-111A  
DTIC AD No.

22 June 2012

CHEMICAL, BIOLOGICAL, AND RADIOLOGICAL (CBR)  
CONTAMINATION SURVIVABILITY,  
SMALL ITEMS OF EQUIPMENT

		<u>Page</u>
Paragraph	1. SCOPE.....	2
	1.1 Background .....	2
	1.2 Purpose .....	3
	1.3 Limitations.....	4
	1.4 General Criteria Evaluation.....	5
	2. FACILITIES AND INSTRUMENTATION.....	8
	2.1 Facilities .....	8
	2.2 Instrumentation.....	9
	3. REQUIRED TEST CONDITIONS.....	12
	3.1 Test Planning .....	13
	3.2 Environmental Documentation (U.S. Only).....	15
	3.3 Safety.....	15
	3.4 Quality Assurance (QA).....	15
	4. TEST PROCEDURES .....	16
	4.1 Chemical Contamination Survivability .....	16
	4.2 Biological Contamination Survivability.....	29
	4.3 Radiological Contamination Survivability.....	37
	4.4 Long-Term CBR Hardness.....	42
	4.5 CBR Compatibility.....	43
	5. DATA REQUIRED.....	45
	6. PRESENTATION OF DATA .....	45
	6.1 Receipt Inspection .....	45
	6.2 Chemical Contamination Survivability .....	46
	6.3 Biological Contamination Survivability.....	47
	6.4 Radiological Contamination Survivability.....	48
	6.5 Long-Term CBR Hardness.....	49
	6.6 CBR Compatibility.....	49

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22 June 2012

APPENDIX	A.	EXPLANATION OF TERMS .....	A-1
	B.	TEST EQUIPMENT .....	B-1
	C.	SUMMARY OF DECONTAMINATION SYSTEM PROCEDURES .....	C-1
	D.	MATERIAL PROPERTIES MATRIX AND DATA TEMPLATE ...	D-1
	E.	ABBREVIATIONS .....	E-1
	F.	REFERENCES .....	F-1
	G.	APPROVAL AUTHORITY.....	G-1

## 1. SCOPE.

### 1.1 Background.

a. The classified U.S. Government Accountability Office (GAO) Report, Chemical and Biological Defense: Sustained Leadership Attention Needed to Resolve Operational and System Survivability Concerns, 30 May 2003 (GAO-03-325C<sup>1\*</sup>), identified several issues related to the ability of key defense systems to survive after being contaminated by nuclear, biological, and chemical (NBC) agents and after being decontaminated. In response to that report, a chemical and biological (CB) contamination survivability (CBCS) implementation plan was developed that was responsive to GAO concerns about the survivability of defense-critical systems and the need for increased management oversight to ensure system survivability. Subsequently, several key elements of that program plan were codified in the Fiscal Year 2005 National Defense Authorization Act (NDAA), Section 1053, Survivability of Critical Systems Exposed to Chemical or Biological Contamination (Public Law ((PL)) 108-375)<sup>2</sup>.

b. Consistent with the PL, on 31 August 2005, the Under Secretary of Defense Acquisition, Technology, and Logistics (USD AT&L) issued an interim Department of Defense (DoD) policy on CBCS<sup>3</sup>.

c. On 9 May 2005, USD AT&L issued a memorandum that established final DoD CBCS policy<sup>4</sup>. The final policy replaced the interim policy and included a process for identifying defense-critical systems that needed to be survivable, instructions on how CBCS should be addressed by the Military Departments, a process for DoD oversight, and definitions of decontamination, hardness, and compatibility.

d. Following the issuing of the DoD CBCS policy, details of how the CBCS policy is to be implemented were written into the DoD Instruction (DoDI) 3150.09<sup>5</sup>, which includes specific responsibilities of all the organizations impacted by the policy and also expands the survivability requirement to include radiological and nuclear survivability. In addition, a chemical and biological materials effects (CBME) database<sup>6</sup> was developed to address another requirement of PL 108-375.

\*Superscript numbers correspond to Appendix F, References.

## 1.2 Purpose.

a. The purpose of this Test Operations Procedure (TOP) is to address chemical, biological, and radiological (CBR) contamination survivability (CBRCS) of small items of equipment.

b. The hierarchy or logic for selection of tests (most desirable because of the information gained to least desirable) is:

(1) Full system agent or simulant testing - full information on the ability of a system to meet the criteria. The use of the actual test item is the most reliable and realistic method for assessing all aspects of the item's survivability. These aspects include assessing for agent trapped in cracks, crevices, between components, in angles, and in odd shapes not easily decontaminable, and evaluating the item's textures and geometry. If it is not feasible and/or cost effective to use the actual item to determine survivability, then based on coordination between the tester, the customer, and the evaluator; testing alternatives will be considered and a choice for testing made.

(2) Scaled-down Testing - a smaller version (e.g., one-quarter scale, etc.) will be used in place of the full-size version of the test item. The test methods described in this document will still be used and adjusted (to include the correct ratio of decontaminant to agent) to provide realistic comparison to full size testing.

(3) Component agent testing - information on the ability of a component or components to meet the criteria; the data can be extrapolated to the full system with appropriate planning. If the component method is selected for testing to represent a large item, the procedures in this TOP will be followed.

(4) Coupons/panels agent testing - information on the ability of a set of materials to meet the criteria; very difficult to extrapolate to the full system. If coupon or panel testing is selected, the panels must be made from the same materials as the large item being evaluated. The procedures in TOP 08-2-061<sup>7</sup> must be followed.

(5) Mock-ups - the mock-ups may be specially fabricated to simulate the test item or may be the actual test item with expensive optical, electronic, or other internal components removed. Mock-ups must be fabricated of the same materials, have the same coatings, and have similar design features as the intended developmental test item. The mock-ups must be furnished and/or approved by the Materiel Developer. The similarities and differences between the mock-up and the test item it simulates will be carefully analyzed and documented.

(6) CBR contamination survivability assessment – an assessment of the expected ability of the system to meet the criteria with the possibility of little or no agent data available for consideration. No actual testing conducted.

c. CBRCS is the capability of a system and its operators to withstand a CBR-contaminated environment, including decontamination, without losing the ability to accomplish

22 June 2012

the assigned mission. Characteristics of CBRCS are decontaminability, hardness, and compatibility; these characteristics are defined in Paragraphs 1.4.a through 1.4.c. Chemical and biological agent must be used to measure decontaminability and hardness for the full cycle (contamination, decontamination, and re-issue to the Warfighter). Simulants may be used in testing. When simulants are used, hardness can only be determined based on effects from decontamination methods, solutions, and/or mixtures. CBRCS should be monitored throughout the materiel acquisition cycle and must be evaluated and assessed during developmental and operational testing.

d. This TOP provides basic information to facilitate planning, conducting, reporting, and standardizing CBR survivability testing of military materiel small items. It is designed to demonstrate that small items of mission-essential (ME) equipment have met the provisions of Army Regulation (AR) 70-75<sup>8</sup> as implemented by the Department of the Army (DA)-Approved Nuclear, Biological, and Chemical Contamination Survivability (NBCCS) Criteria for Army Materiel<sup>9</sup> and outlined in Quadripartite Standardization Agreement (QSTAG) 747, edition 1<sup>10</sup>. DoDI 3150.09 outlines CBRCS requirements for mission-critical systems. To survive CBR contamination, materiel must meet criteria for decontaminability, hardness, and compatibility<sup>9</sup>. This TOP describes typical facilities, equipment, and procedures used to contaminate equipment, sample for contamination density, decontaminate, sample for residual contamination, determine degradation of ME functions resulting from the contamination and/or decontamination (C/D) procedures, and analyze crew/test-item compatibility. Neutron-induced gamma activity (NIGA) is not addressed in this TOP. Information on NIGA and initial-blast effects can be obtained from other sources (e.g., Field Manual (FM) 3-11.3<sup>11</sup>, and Allied Tactical Publication (ATP) 45C<sup>12</sup>).

e. The acronyms, CB and CBR, are used in this document, rather than NBC, to reflect current terminology in use within the DoD. North Atlantic Treaty Organization (NATO) documentation still uses the term NBC, and this will be reflected in references within this document.

### 1.3 Limitations.

a. This TOP only provides standard procedures for testing the contamination survivability of small items of equipment, such as equipment carried by an individual Warfighter and removable sensitive equipment.

b. When testing is conducted using simulants for chemical warfare agents (CWAs) or agents of biological origin (ABOs) without a corresponding agent/simulant correlation or relationship, the test data must not be used without the establishment of the agent/stimulant relationship. Additional information on the physical parameters that are being simulated must be included in test reports. Overall, it must be noted that simulants do not represent CWAs/biological warfare agents (BWAs) in many properties. A simulant will be used to test for radiological contamination survivability. While there is one preferred radiological simulant, it should be noted that there are still limitations associated with using a simulant rather than actual radiological material.

c. The procedures for radiological decontamination in this TOP pertain only to removal of simulated radioactive fallout particles or fallout from a radiological dispersal device (RDD). Radiological contamination survivability testing of equipment and systems, as specified in the NBCCS criteria<sup>9</sup>, includes NIGA and activity resulting from fallout of radioactive dust and debris. The induced activity creates physical changes to materiel properties, which remain even after removal of the radioactive dust and debris. Therefore, when determining the radiological contamination survivability of an item, the contributions from both sources must be considered. However, induced radiation cannot be removed or reduced by present CBR-field decontamination materials and procedures, and induced activity hazard testing requires different facilities, instruments, and safety considerations from those described in this document. Survivability from immediate nuclear blast effects and NIGA are not covered in this TOP.

d. The only criteria for CBRCS as listed in this TOP are for the Department of the Army<sup>9</sup>. Although there is an AR<sup>8</sup> and a DODI<sup>5</sup> covering CBRCS policy, there are no additional criteria. For acquisition programs that have CBRCS requirements, the default is to use the DA criteria<sup>10</sup>. These criteria are not for use in determining decontamination efficacy, but only CBRCS.

e. There are many factors that can affect the performance and/or survivability of a system before and after the conduct of decontamination operations. Many of these factors cannot be evaluated for their effects. An example would be the age of the paint on the surface (aged, new, etc.).

f. The only current mechanism for converting agent mass from solid sorbent tubes (SSTs), bubblers, or concentrations collected by MINICAMS (a miniature, automatic, continuous air-monitoring system) is to use a downwind hazard prediction model<sup>13</sup>. Once a decontamination system performance model is developed with the necessary toolset, then that model may replace the current model.

g. This TOP does not, nor does it intend to, identify or predict all scenarios and conditions that may be applicable to CBRCS testing. Therefore, coordination with the combat and material developers and the use of appropriate threat documents is imperative in developing an operationally realistic environment and a comprehensive test. The evaluator will participate in determining the number of test events necessary for each chemical, biological, radiological, and nuclear (CBRN) mission-critical system, ensuring statistical significance. This allows for successful extrapolation and assessment of CBRCS test results for the interiors of CBRN mission-critical systems.

h. The compatibility portion of CBRCS will not be addressed in this TOP. Compatibility of operation while wearing personal protective ensemble is more efficiently addressed during operational testing.

#### 1.4 General Criteria Evaluation.

The following procedures must be used to evaluate the ability of the test item to meet the criteria for decontaminability, hardness, and compatibility.

#### 1.4.1 Decontaminability.

##### a. Chemical.

(1) Vapor Hazard. The effective concentration of agent vapor desorbed over time is  $C_e$ . The mission time provided by the user is  $t$ . Then  $C_e t$  = dosage, which should be compared with the appropriate criteria<sup>9</sup>.

(a) Traditional vapor samplers (bubblers and SSTs) sample vapor streams for discrete periods of time defined by a sampling plan. The bubbler solvent containing agent or the SSTs with agent residing on the sorbent are analyzed and the mass of residual agent quantified. The volume of agent-containing air is determined by using critical orifices to restrict the airflow through the sampler and flow rating the critical orifice on the upwind side before and after the sampling period. The two flow rates allow a determination of whether or not the airflow through the sampler changed over time. The mass of agent is used to calculate the average concentration during the sampling period by multiplying the mass times the volume of air that passes through the sampler. The dosage is calculated by multiplying the concentration by the time of sampling and then accumulating the dosage for all sample periods for a total dose.

(b) The MINICAMS is being used to replace the traditional vapor samplers as a near-real time (NRT) analytical method. The MINICAMS reports concentrations. The air-sampling rate is controlled by a mass flow controller at 0.5 meters per second (m/sec). The sampling times (sample then analysis and purge) range from 3 to 15 minutes. The concentration can be multiplied by the total sample time for a total dose.

(c) The size of the enclosure or vapor off-gas box used on test items can significantly affect the residual vapor data collected and must be given serious consideration when designing the test. If a small test item is placed in a large off-gas box, then the residual agent vapor can be diluted in the large volume of air in the box resulting in an underestimation in the calculation of the concentration and total dose. Likewise, if a small test item is placed in an off-gas box only slightly larger than the item, then the residual agent vapor has a large presence in the smaller volume of air resulting in an overestimation in the calculation of the concentration and total dose.

(d) In order to deal with the issue of the volume of the off-gas box, new methodology has been developed that normalizes the volume of the off-gas box used. Instead of reporting only a concentration or total dose, the toxic load of the airflow is calculated and used to characterize the test item emission rate. The emission rate can then be used to develop multiple scenarios with the test item and determine if any of the scenarios represent a vapor hazard. This new methodology can be found in the Baseline Source Document Chemical Decontaminant Performance Evaluation Testing<sup>14</sup>.

(2) Contact Hazard. The mass collected by the contact samplers should be adjusted for the average area of human contact with the item. This value should be compared with the appropriate mass value in Table 1 of the criteria for Army materiel<sup>9</sup>.



b. Biological. The colony forming units (CFUs) (spores that have become viable cells) that are sampled after decontamination are divided by the number of CFUs sampled after contamination of the test item. This ratio is then expressed as the log reduction and compared with the appropriate criteria<sup>9</sup>. The criteria are based on a spore count, and because it is impossible to realistically count individual spores, a CFU reduction of 6 logs (i.e., reduced by a factor of one million) is used instead. If the system CFU reduction is  $\geq 6$  logs, then the system has successfully met the criterion for biological decontaminability.

c. Radiological. For radiological testing, simulants are used. The simulants may include non-radioactive isotopes or short half-life isotopes. The method of evaluation is to use the value of the post-contamination sample and subtract the value of the post-decontamination sample. The resulting difference is divided by the value of the post-contamination sample and multiplied by 100 to determine the decontamination efficacy.

(1) If the value for decontamination efficacy for short half-life isotopes is less than or equal to the criterion<sup>9</sup>, then the item is considered to have successfully met the criterion for radiological decontaminability.

(2) The value for decontamination efficacy for non-radioactive isotopes will be compared with the particulate challenge to determine the reduction of particulate matter. This assumes that a reduction of 50 percent of the radioactivity<sup>9</sup> is equivalent to a 50 percent reduction of particulate matter.

#### 1.4.2 Hardness.

CBR hardness is “the capability of materiel to withstand the material-damaging effects of CBR contamination and relevant decontaminations”<sup>5</sup>. Hardness of mission-critical materials against CBR contamination and decontamination may be tested at the coupon level in accordance with (IAW) TOP 08-2-061. Changes in critical physical/performance parameters will provide insight as to how the system may function following C/D. At times, the system will not be tested against CWA or BWA but against a simulant. Under these conditions, the only meaningful data will be the hardness of the material/system to the decontamination process.

a. The ME function characteristics will be obtained from the Material Developer (i.e., voltage output, airflow, pressure, etc.).

b. The ME function characteristics will be measured on the as-received item for baseline functional performance.

c. The C/D cycles will be performed. The same parameters will be measured after each cycle.

d. Pre- and post-C/D measurements will be compared to obtain the percent degradation (if any).

22 June 2012

e. Long-term effects (30 days or greater), as outlined in test documentation (such as air worthiness considerations), will include additional measurements of the selected function parameters at scheduled time intervals.

f. Multiple cycles of C/D (more than the usual five cycles) also need to be considered in cases related to biological contamination not related to BWAs and regular transits from the United States (U.S.) to outside the U.S. (usually aircraft). This consideration is intended for military materiel in a civilian environment.

#### 1.4.3 Compatibility.

The ability to obtain data during developmental or laboratory testing is extremely limited and may have to be obtained during operational testing. Functions relating to the operation of the system being tested are measured while wearing normal uniforms and mission-oriented protective posture, level IV (MOPP IV). The percent difference in task performance is calculated, and if it is less than 15 percent, the system has successfully met the criterion for compatibility.

a. The ME Warfighter tasks will be obtained from the user for the equipment under evaluation.

b. Tasks will be performed in the operator's standard garment.

c. Tasks will be performed in the protective ensemble.

d. Task performance and effectiveness of the operator(s) in standard garment versus protective ensemble will be compared.

## 2. FACILITIES AND INSTRUMENTATION.

### 2.1 Facilities.

Facilities, instrumentation, and safety procedures used for CB survivability testing are strictly controlled. Additional discussion and requirements for facilities and instrumentation are included in the test procedures (Paragraphs 4.1 through 4.5).

<u>Item</u>	<u>Requirement</u>
Chemical-surety laboratory and chemical agent storage facility.	Constructed to ensure safe and secure storage, handling, analysis, and decontamination of chemical agents and/or simulants used for surety materiel.

<u>Item</u>	<u>Requirement</u>
Chemical-agent test facility or chamber.	Constructed to allow C/D and extended residual hazard sampling of small items of equipment deliberately contaminated with chemical agent/simulant in a temperature and humidity controlled environment. The chamber should have sufficient volume to allow free air circulation around the test item. Ability to control temperature, relative humidity (RH), and wind speed is required.
Fielded decontaminating apparatus, as specified in the concept of operations (CONOPS).	Constructed to decontaminate the test item as part of the test procedure.
Biological analytical laboratories.	Required to store and prepare test quantities of biological agent/simulant materials, to charge disseminating devices, to prepare samplers, and to analyze all biological agent/simulant materials.
Radiological simulant/isotope analytical laboratories.	Required to store and prepare test quantities of radiological contamination simulant materials, to charge disseminating devices, to prepare samplers, and to analyze all radiological simulant/isotope materials.
Chambers for biological and radiological simulant testing.	The chamber should be equipped with an air intake and an exhaust system, and should have sufficient volume to allow free air circulation around the test item. Biological surety regulations will be followed if biological surety material is used at any time. Ability to set and maintain temperature and RH is highly desirable.

## 2.2 Instrumentation.

These values are minimum requirements. Actual instrumentation may have greater precision, and actual values should be reported.

<u>Parameter</u>	<u>Measuring Device</u>	<u>Permissible Error of Measurement</u>
Air temperature (-20 to 50 °Celsius (C)).	Thermocouple or other.	± 0.5 °C.

<u>Parameter</u>	<u>Measuring Device</u>	<u>Permissible Error of Measurement</u>
RH (0 to 90 percent).	Humidity probe or other.	± 2 percent.
Airflow (0 to 5 m/sec).	Anemometer or other.	± 0.1 m/sec.
Photographs.	Still color camera.	Adequate to document typical test procedures, details of contamination techniques and contamination density (including mass median diameter (MMD) of drops), and any discrepancies from planned procedures necessitated by operational conditions.
Video.	Video camera.	Adequate to document typical test procedures, details of contamination techniques and contamination density (including MMD of drops), and any discrepancies from planned procedures necessitated by operational conditions.

### 2.2.1 Chemical Test Instrumentation.

These values are minimum requirements. Actual instrumentation may have greater precision, and actual values should be reported.

<u>Parameter</u>	<u>Measuring Device</u>	<u>Permissible Error of Measurement</u>
Contamination density or challenge level (g/m <sup>2</sup> ).	A control coupon will be used for the calculation of the actual contamination density applied.	± 15 percent of calibration standard.
Chemical agent mass from vapor samples (µg).	MINICAMS, gas chromatograph (GC), high-performance liquid chromatography (HPLC), liquid chromatography (LC), spectrophotometer, or equivalent.	± 15 percent of calibration standard.
Chemical agent mass from liquid samples (µg).	GC, HPLC, LC, spectrophotometer, or equivalent.	± 15 percent of calibration standard.

### 2.2.2 Biological Test Instrumentation.

These values are minimum requirements. Actual instrumentation may have greater precision, and actual values should be reported.

<u>Parameter</u>	<u>Measuring Device</u>	<u>Permissible Error of Measurement</u>
Background contamination.	Microscopes, swabs or wipes placed in growth medium, automatic colony counters, or equivalent.	$\pm 10$ percent CFU/sample.
Post-contamination verification.	Microscopes, swabs or wipes placed in growth medium, automatic colony counters, or equivalent.	$\pm 10$ percent CFU/sample.
Post-decontamination.	Microscopes, swabs or wipes placed in growth medium, automatic colony counters, or equivalent.	$\pm 10$ percent CFU/sample.

### 2.2.3 Radiological (Simulant) Test Instrumentation.

These values are minimum requirements. Actual instrumentation may have greater precision, and actual values should be reported.

<u>Parameter</u>	<u>Measuring Device</u>	<u>Permissible Error of Measurement</u>
Contamination measurement (background, post-contamination, and post-decontamination).	Non-isotope challenge: Microscopes or equivalent.  Isotope (non-radioactive or short half-live) challenge: GC/mass spectrometry (MS), radiation detector, or equivalent.	$\pm 5$ percent particles/m <sup>2</sup> .  To be determined based upon instrument used.

#### 2.2.4 CBR Hardness Test Instrumentation.

<u>Parameter</u>	<u>Measuring Device</u>	<u>Permissible Error of Measurement</u>
ME functions as described in specific CONOPS	As necessary (optical haze, transmittance, durometer, tensile strength, etc.).	Precision and accuracy requirements must be compatible with the nature of the test item and type of function, but must allow for the detection of 20 percent degradation in the ME performance characteristic after completion of each of the required C/D cycles

#### 2.2.5 CBR Compatibility Test Instrumentation.

<u>Parameter</u>	<u>Measuring Device</u>	<u>Permissible Error of Measurement</u>
Operator performance tests.	Stop watches or equivalent. Operator/crew ME functions (e.g., operating a computer, conducting maintenance operations, etc.) are timed and/or accuracy based functions. The standards for ME functions are outlined in system-specific doctrinal and training publications or are established by the Combat Developer for that system. The difference between the function performed with duty uniform and with MOPP IV allows a determination of the percent degradation.	Precision and accuracy requirements must be compatible with the nature of the test item and type of function being studied, but must allow for the detection of 15 percent degradation in the item/operator ME function performance in five trials or less.

### 3. REQUIRED TEST CONDITIONS.

a. CBRCS testing requires the handling and use of chemical agents. Such testing is strictly controlled by regulations (e.g., AR 385-10<sup>15</sup>, DA Pamphlet (PAM) 385-61<sup>16</sup>, and DA PAM 385-69<sup>17</sup>). Throughout testing, primary emphasis must be on operator and test safety. The importance of technical quality, completeness of test data, and conformance with specified test and operating procedures should be emphasized.

b. The required test parameters<sup>9</sup> are a temperature of  $30 \pm 2.0$  °C and airflow across the test item less than 1.0 m/sec. There is no requirement for RH.

### 3.1 Test Planning.

a. Each CBRCS test plan must be reviewed for technical accuracy and conformance to regulations and Standing Operating Procedures (SOPs) applicable to the specific item and tests being conducted. In addition, the test plan must accurately reflect the requirements outlined in capabilities documents. Published test records, procedures, and the case files of similar test items must be reviewed to identify potential problem areas that are difficult to decontaminate. All SOPs and procedures must be reviewed for current, adequate, and complete information.

b. The capabilities documents (Initial Capabilities Document (ICD), Capability Development Document (CDD), or the Capability Production Document (CPD), the CONOPS, and Failure Definition/Scoring Criteria (FD/SC) will be reviewed. The Operational Test Agency (OTA) Evaluation Plan (OEP) and the Test and Evaluation Master Plan (TEMP) will be used to determine the overall test structure, data required, criteria, and analysis to be used. The ME function, performance characteristics, and the ME Warfighter tasks specified by the Materiel Developer and the Combat Developer, respectively, will be listed. These will be used to measure degradation in performance caused by CBR C/D and by the need for the operator to wear the CBR protective ensemble. Units of measurement and the accuracy and precision required for each parameter measured will be identified. All issues concerning measurable performance and degradation will be reviewed.

c. Based on the information collected from the capabilities document, the OEP, the TEMP, and in coordination with the customer, the number of test items and the number of C/D cycles that need to be conducted on the system under test (SUT) will be determined. NATO QSTAG 747 dictates that a default of five C/D cycles will be conducted on each test item to accommodate a radiological cycle, a biological cycle, and three chemical agent cycles for the three classes of CWA outlined in the QSTAG. It is possible that less than, or more than five cycles, may be required.

d. A realistic test-item sample size (based on test cost, as well as test item size, value, and availability) will be determined through review and coordination with the assigned operational test-activity evaluator. The sample size may be determined by test-item availability, cost, or other factors and may be less than optimum. If sample size is less than optimum, a testing scheme will be devised to optimize test-item use and required data output. The use of design-of-experiment will be considered in developing the test matrix.

e. Representative areas of the test item to be sampled for residual contamination will be selected and identified. If the entire test item/system cannot be contaminated and decontaminated, then representative areas for contamination, decontamination, and sampling will be selected. Selection of the sample locations will depend on consideration of overall test-item size, geometry of the test item, materials of construction, surface texture, presence of joints and crevices, areas handled/touched by system operators, and the likelihood to contribute to crew vapor and contact hazard. Because of the nature of liquid (contact) sampling devices, sample locations need to be flat or nearly flat. An appropriate number of such areas will be selected to help assure the statistical validity of the resulting sample size. The test plan will identify and explain the rationale for the areas selected and the statistical-analysis methodology used. The

22 June 2012

test report will identify any changes from the test plan. Each sample location selected must be described and photographed. No additional marks should be placed within the marked boundaries of the locations to be sampled.

f. C/D cycles will be conducted using CBR agents and/or simulants and fielded decontamination systems and procedures. Actual survivability can only be confirmed by using actual agents. The default chemical agents<sup>9</sup> are persistent nerve agent (VX), distilled mustard (HD), and thickened soman (TGD). A biological simulant is used in place of an ABO. Decontamination systems and decontaminants include, but are not limited to: the M291 skin decontamination kit; the M295 Individual Equipment Decontamination Kit (IEDK); the M100 sorbent decontamination system; the M12; the M17; hot soapy water (HSW); and supertropical bleach (STB). Field-expedient decontaminants include, but are not limited to: high-test hypochlorite (HTH, a STB substitute); household bleach solutions (usually a ratio of one part bleach to ten parts water); alcohol-wetted cloth (for sensitive equipment); and low-pressure, high-volume water. A brief summary of these decontamination system procedures is found in Appendix C.

g. If the system consists of materials similar to other systems already tested (either systems' cases are the same thermoplastic, or both systems are radios with one being larger than the other), then consideration may be given to conducting a CBR materiel survivability assessment as a cost-saving measure. Coordination with the test sponsor and the OTA conducting the system evaluation must occur before implementing this option. The test-item design and the materials of construction will be examined. The materials of construction will be reviewed to see if any data can be found in the CBME database<sup>6</sup>, and an analysis will be performed based on previous test experience and technical information concerning the material's ability to survive exposure to contamination, decontaminants, and the decontamination process. If there are material effects data in the CBME, then it can be reviewed for applicability to the current system. Any areas where agent could pool or seep, such as cracks, crevices, hinges, joints, countersunk screw heads, or other difficult to decontaminate features, will be noted. It is recommended that any identifiable vulnerabilities, or questionable design or materials are adequately tested. If the examination of the system design and the materials of construction reveal any aspect of design or identify a material that appears to make test failure probable, testing of the system or material should be performed early in the test cycle. Preliminary results can often be determined from a pilot study and analysis of the collected information. The report of the survivability assessment will detail the expected ability of the system to meet the CBCS criteria<sup>9</sup>.

h. For tests involving the use of simulants, qualified and trained operators and standard equipment (decontamination, maintenance, and calibration, etc. that Warfighters would use with the system) must be scheduled. If Soldiers are desired, ensure a Test Schedule and Review Committee (TSARC) request is submitted within one year from the start of testing or as early as possible. Standard decontamination procedures will be developed for the test item, if required. Before testing begins, rehearsals must be held to familiarize the test team with the functioning of the test item, test procedures, and data requirements. The team must practice using simulants until agent-dispensing, decontamination, and sampling become routine. The test item used during the actual test should not be used in rehearsals with simulants unless it is the only test



item available and testing will be conducted outdoors. It is recommended that one or more dry-runs be performed to give operators an opportunity to demonstrate, standardize, and confirm test procedures.

i. For tests involving threat agents, the appropriate laboratory will be scheduled to conduct the test, and laboratory technicians will receive appropriate system operating training before testing begins.

### 3.2 Environmental Documentation (U.S. Only).

An environmental assessment (EA) must be on file covering the storage, use, and disposal of the simulants, hazardous and contaminated materials, and agents used in CBRCS testing. The assessment must fully address the potential environmental impact of the specific survivability testing planned. The test plan must cite the EA and/or a record of environmental consideration (REC) that cites the EA and the appropriate categorical exclusion. The REC must be approved before testing begins. If the planned survivability testing is not adequately addressed in the existing EA, an EA specifically addressing the survivability testing to be conducted must be prepared, as required by the National Environmental Policy Act (NEPA) of 1969 PL 91-190<sup>18</sup>, and AR 200-2<sup>19</sup>.

### 3.3 Safety.

Applicable safety, SOPs, and surety regulations will be reviewed to ensure compliance of all test procedures.

### 3.4 Quality Assurance (QA).

Controls and limitations applicable to a specific subtest are presented in Section 4 as part of the procedure to which they apply.

a. A QA plan must be prepared for each test program to ensure that all variables that can be controlled are controlled and that appropriate records are kept throughout the duration of testing. Variables that cannot be controlled must be identified in the test plan. Test variables include, but are not limited to: purity and stability of agents and simulants used, purity and stability of decontaminants, calibration and maintenance of instrumentation and disseminators, accuracy and precision of the laboratory analysis, and quality and uniformity of all test samples.

b. The condition of the test item at the time of testing is an important test variable. Unless receipt inspection was part of a subtest completed before CBRCS testing, the test item should be inspected IAW TOP 08-2-500<sup>20</sup>. Inspection data, certificates of compliance, or similar documentation, should be reviewed to ensure that exterior surfaces, finishes, and packaging meet specifications. Generally, the item should be tested in as-received condition, matching its condition when issued to Warfighters in the theater of operations as closely as possible. CBRCS testing may be required periodically throughout the equipment life cycle if the effect of normal wear is a major factor in survivability.

22 June 2012

c. Decontamination. Existing system-specific decontamination procedures using fielded decontaminants or developmental decontaminants should be reviewed and incorporated into the planned test as much as possible. Any deviations from existing procedures in the test plan must be documented in the test report.

d. Test Conduct. Testing must always be conducted IAW approved test documentation, such as technical manuals, field manuals, equipment operating instructions, SOPs, the approved test planning directive, OEP, TEMP, and the test plan. Deviations from test documentation will be put in writing and approved by the appropriate authority as part of the test plan and report production.

#### 4. TEST PROCEDURES.

The CBR components of CBR contamination survivability testing are addressed separately in Paragraphs 4.1 through 4.3. Although the test methods are similar, subtle but important differences exist. Long-term CBR hardness and CBR compatibility are discussed in Paragraphs 4.4 and 4.5.

##### 4.1 Chemical Contamination Survivability.

###### 4.1.1 Objectives.

a. Decontaminability. Determine the ability of a system to be rapidly (less than 75 minutes<sup>9</sup>) and effectively decontaminated following chemical agent exposure. Measure the vapor and percutaneous hazards, including eye effects, associated with Warfighter use of equipment that has been contaminated with chemical agent and decontaminated using standard and/or item-specific decontamination procedures.

b. Hardness. Determine the capability of a system to withstand the material damaging effects of chemical agent and relevant decontaminations. Measure the degree of performance degradation in ME functions of military ME materiel after chemical agent C/D by standard and/or item-specific procedures.

c. Compatibility. Determine the degree of degradation in ME Warfighter tasks as a result of operating a piece of equipment in protective ensemble (e.g., MOPP IV).

Note: The process for identifying mission-critical equipment is outlined by DoDI 3150.09. ME functions are those functions that define the successful completion of a mission for the system or equipment being tested as defined by the test sponsor and/or Combat Developer in the FD/SC.

#### 4.1.2 Criteria and Conditions.

##### 4.1.2.1 Criteria.

a. Mission-critical equipment shall be hardened to ensure that exposure to the specified C/D cycle does not degrade the operational ME performance of the equipment more than 20 percent (or that specified by the Combat Developer) measured over a 30-day period<sup>9</sup>, or as defined by the capabilities documents.

Note: As an example, if the faceplate of a protective mask had a transmittance of 99 percent and after five cycles of decontamination the transmittance is measured as 97 percent, then the degradation is calculated as  $(99 - 97)/99 \times 100 = 2$  percent.

b. The exterior surfaces of materiel developed to perform ME functions shall be designed so that chemical contamination remaining on or in the item or desorbed from the surface following decontamination shall not result in more than a negligible risk (5 percent mild incapacitation) to unprotected individuals using the equipment or within 1 meter of the item/equipment after chemical agent C/D as stated in the criteria<sup>9</sup>.

##### 4.1.2.2 Conditions.

General conditions are as follows:

a. Selected exterior areas will be initially uniformly contaminated (random drop pattern over the selected area) to a contamination density as specified in the system threat assessment and capability documents (default of 10 g/m<sup>2</sup>) with 5 to 10 microliter (μL) drops of TGD and 2 to 5 μL drops of HD, or VX. The CWAs, VX, HD, and TGD, are required for testing by the DA-Approved NBCCS Criteria for Army Materiel<sup>9</sup>. The selection of areas to be contaminated is based upon the concept that there will be a “rain” of airborne contaminant onto items. The “rain” is usually defined as coming from a 30-degree angle from vertical. Therefore, there is an expectation that only the top, one side, and one end of the test item will become contaminated.

b. The purity of the chemical agents used must be known and recorded as test data. A purity certification must be provided with the agent used for testing and the certificate issued within the last 12 months. The quantity applied may be adjusted to achieve the required pure agent contamination density. If weapons-grade agent is used, the purity must be measured and recorded as test data. If simulant testing is necessary, a simulant/agent correlation must be fully documented.

c. The amount of time between contamination and the start of decontamination operations (often called weather time) will depend on requirements in capability documents. The default weather time is 60 minutes. Given changes in battlefield doctrine, the default weather time may not be representative of the actual travel time from a contamination site to a decontamination site. Weather time should be coordinated with the test sponsors and Combat Developers. Standard field and/or item-specific decontaminants, equipment, and procedures will be used if they exist and are available. The decontamination procedure conducted and time

between C/D will be included in the test plan for each system or equipment item. The decontamination process time (excluding point detector monitoring) will be recorded.

d. The chamber and item surface temperature will be 30 °C, and exterior wind speed will be no greater than 1 m/sec<sup>9</sup>.

#### 4.1.2.3 Controls and Limitations.

The controls and limitations for chemical agent/simulant contamination survivability testing are:

a. Surface of the Test Item.

(1) Surface areas selected for sampling must be representative of the surface materials, texture, paint, and areas where the user will have direct contact.

(2) Before each trial, the surfaces of the test item must be inspected and sampled (vapor and contact) for background contamination. Any foreign substances on the test item surface that could interfere with sampling the surface or with analytical instrumentation must be removed (e.g., with inert solvent, HSW, etc.) before testing.

b. Analysis control data include standard analytical controls (see Paragraph 4.1.4.6). The standards need not be at equal concentration intervals; rather, they should be spaced closer together near the low-concentration end of the calibration curve IAW SOP DP-0000-M-073<sup>21</sup>.

c. Test controls (vapor and contact) should include:

(1) Vapor only: non-operated sampler control (a sampler taken into the area surrounding the test item but not used, opened, or aspirated).

(2) Vapor only: operated sampler control (a sampler taken into the area surrounding the test item and used, opened, or aspirated, but not exposed to agent or simulant).

(3) Positive control, which is a test item or coupon contaminated but not decontaminated.

(4) Negative control, which is a test item or coupon that is not contaminated, but is decontaminated.

d. Instrument calibration will be recorded as part of the test record and will include the calibration requirement (yearly, semiannual, etc.).

e. Threat agent tests will be conducted inside a surety test facility (chamber) approved for use with chemical agents.

#### 4.1.3 Data Required.

The following data will be reported in the units indicated:

- a. Test chamber/hood.
  - (1) Temperature in °C.
  - (2) RH in percent.
  - (3) Wind speed (airflow) in m/sec.
- b. Agent or simulant.
  - (1) Name and control number.
  - (2) Purity in percent.
  - (3) Viscosity after adding thickener (if thickened) in centistokes (cSt).
  - (4) Age since thickened, if thickened.
  - (5) Name, product identity, and manufacturer of dye (if used).
  - (6) Quantity of dye and/or thickener (if thickened) in g/L.
  - (7) Quantity of agent/simulant dispensed in g.
  - (8) Agent/simulant contamination density in g/m<sup>2</sup>.
  - (9) Agent/simulant drop diameter in mm.
  - (10) Agent/simulant drop volume in µL.
- c. Results of each post-decontamination agent/simulant vapor and contact sample (collected during the 12-hour sampling period) in µg/sample.
- d. Results of the sampling and analysis controls and standards in µg/sample.
- e. Sample history with elapsed time to analysis in days.
- f. Complete description of the contact sampler used (material type, lot number, diameter, thickness, and any other pertinent information). Description of any contact sampler efficacy and/or solvent extraction efficacy studies conducted on the contact sampler and solvent used for extraction.

22 June 2012

- g. Contamination, weathering, decontamination, and sampling times in minutes.
- h. Description of the decontamination solutions (i.e., formulation, active ingredients, lot number, and age), methods, equipment, and item-specific procedures used.
- i. Description and photographs of the test-item exterior surface condition (pretest), including construction materials, paint type, paint thickness (number of coats), paint condition, and surface cleanliness (mud, grease, and other).
- j. Pretest (baseline) and posttest (30 days after the first contamination and/or other defined long-term time interval) ME functional performance data, recorded to the highest level of accuracy and precision commensurate with the parameter being measured.
- k. Descriptions and photographs of test-item cracks, crevices, and other features that could allow contaminants or decontaminants to penetrate below the surface and may be difficult to decontaminate.
- l. The stain size on the surface, if any, caused by the drops, if safety procedures permit and if this information is desired.
- m. A description of the required contact-sampling times specified.
- n. Description and photographs of any materials degradation (e.g., corrosion).
- o. Identification of the C/D cycle event.
- p. Relevant safety findings as a result of testing.
- q. Test-item description.
- r. Total surface area contaminated.
- s. Interior volume of vapor sampling boxes.

#### 4.1.4 Methods and Procedures.

##### 4.1.4.1 Test Method Outline.

a. Receipt inspection will be conducted to document as-tested material conditions. Receipt inspection may include functional performance tests to establish baseline performance parameters (e.g., computer is operational, aircraft avionics are operational). Paragraph 4.1.4.7 describes the details for this step of the test method.

b. The agents/simulants will be prepared for application as described in Paragraph 4.1.4.8.

c. Test item will be prepared for testing, to include sample location, identification and documentation; marking of sample areas; etc. Paragraph 4.1.4.9 describes the details of this step.

d. Laboratory hood or test chamber operation will be verified and environmental conditions for the test stabilized. Environmental conditions are monitored, the test item is allowed to equilibrate with the ambient conditions, and any required background samples are taken before contamination IAW Paragraph 4.1.4.10.

e. Agents/simulants are applied to the item under test. Paragraph 4.1.4.11 describes the details of this step.

f. Decontamination operations will be conducted on the item under test as described in Paragraph 4.1.4.12.

g. Post-decontamination vapor and liquid (contact) sampling and sample analysis will be conducted as described in Paragraph 4.1.4.13.

h. Sample analysis will be performed (Paragraph 4.1.4.14).

i. Hardness determination, including post-decontamination functional performance measurements, will be performed IAW Paragraph 4.1.4.15.

j. Data presentation and hazard determination will be performed IAW Paragraph 6.2.

#### 4.1.4.2 Significance and Use.

a. The sample data collected from this test allow a determination of contact and vapor hazards to unprotected personnel from decontaminated military materiel.

b. The functional performance and/or material effects data collected allow a determination of the amount of physical or functional degradation of the system resulting from CB C/D procedures and materials to determine if there is a hardness issue.

c. A fundamental assumption is that ambient laboratory environmental conditions are sufficient for test method conduct.

#### 4.1.4.3 Interferences.

There are no interferences when the test method is conducted under laboratory-controlled conditions.

#### 4.1.4.4 Apparatus.

a. The term apparatus will be used to cover the test fixture in which a test method may be conducted, as well as the equipment used in conducting testing, sampling, and analytical instrumentation.

b. Special fixtures may be required for vapor sampling because of the wide variety of systems that could be tested. Some fixtures will have to be manufactured to fit the size of the test system and still remain in an agent-capable fume hood or chamber. Each fixture should be capable of maintaining airflow around the test item, allowing operators to easily reach the test item for agent application, decontamination, and to perform contact or residual liquid sampling. Additional methodology may be required to perform vapor sampling (see Paragraph 4.1.4.13).

c. The instrumentation used in test method conduct, sampling for residual liquid and vapor, and the analytical equipment for sample analysis are found in Paragraphs 2.2 and 2.2.1.

#### 4.1.4.5 Hazards.

a. Identified safety hazards are those associated with testing using toxic chemical surety materials, simulants, and decontaminant chemicals that are hazardous in and of themselves (e.g., chlorine, hydrogen peroxide). Chemical safety guidelines are found in DA PAM 385-61.

b. A test plan must be developed with a safety section identifying and addressing all safety concerns for each test conducted using these methods IAW AR 385-10. The safety section of the test plan will be coordinated with the test site's safety office.

#### 4.1.4.6 Calibration and Standardization.

a. General chemical analytical calibration guidelines are found in SOP WDC-ANA-004<sup>22</sup>. These guidelines can be used for most chemical analytical equipment (e.g., GCs, LCs). A sample sequence will be created that includes the following:

- (1) A solvent blank to evaluate method interferences.
  - (2) Calibration standards (ranked low to high or high to low) with at least five standards. Preparations of standards are described in SOP DP-0000-M-073.
  - (3) A solvent blank to evaluate carryover.
  - (4) Quality control (QC) sample to validate the calibration curve, at least one sample per detector (if multiple detectors are installed on the same instrument) including control samples.
  - (5) Another solvent blank.
- b. The same method will be used to analyze all samples.
- c. Using the instrument software (where available), the calibration curve will be built from lowest to highest.
- d. Plot information will be evaluated as follows:



- (1) Curve fit type (linear, quadratic, etc.) will be selected.
  - (2) Point weighting (equal, inverse, etc.) will be selected.
  - (3) If correlation value ( $R^2$ ) is greater than 0.995, then analysis will proceed.
  - (4) If  $R^2$  is less than 0.995, then one data point can be removed and the calibration curve recalculated.
  - (5) If correlation still fails, each data point will be evaluated to determine any errors.
  - (6) Method adjustments will be made and the calibration repeated.
  - (7) If correlation fails, help within the organization will be requested.
- e. If all criteria are met, the QC sample will be loaded and processed against the calibration curve.
  - f. The calculated values for the QC sample must be within  $\pm 15$  percent of the expected value.
  - g. If the QC calculated value passes, then the test method will proceed.
  - h. If the QC calculated value fails, then a second QC sample will be run.
  - i. If the second QC calculated value passes, then the test method will proceed.
  - j. If the second QC calculated value fails, then corrective actions and recalibration will be performed to the instrument.
  - k. After any maintenance action to the instrument, two QC samples must pass the  $\pm 15$  percent criteria or corrective actions and recalibration must be performed.

#### 4.1.4.7 Receipt Inspection and Functional Performance.

- a. Test items must be inspected for shipping damage, completeness of assembly, required accessories, and necessary manuals, logbooks, etc. Any missing components, damage, or other discrepancies noted will be documented.
- b. Surfaces will be inspected for foreign materials normally not present on the item (dust, mud, grease, or marking). Foreign materials may be removed by brushing, vacuum cleaning, or washing with soapy water and sponge. The removal of foreign materials will minimize the bias that could create an over/under estimate of the true contamination survivability of the system being tested. The surface condition, surface cleanliness, corrosion, materials of construction, variance from standard painting, and paint condition will be recorded.

c. The test item will be operated IAW the operator's manual. ME functional performance characteristics (e.g., electronic functions, shelter setup) identified by the Combat Developer (e.g., in the FD/SC) must be measured and recorded. Based on the selected functional performance characteristics, each functional performance characteristic should be designated as either a functional performance attribute (GO or NO-GO) or as a functional performance variable measured over a continuous range of values. Each parameter must be measured at least twice and must be recorded to the smallest significant unit of measure. If any damage, surface condition, or ME functional performance characteristic falls outside developer specifications, then testing will not proceed.

#### 4.1.4.8 Agents/Simulants.

a. The agents to be used are as follows:

(1) Neat VX with a purity greater than 85 percent, unless weapons-grade is desired (SOP WDC-ANA-031<sup>23</sup>). The agent may be prepared with approximately 0.5 percent (weight/volume) of a suitable dye (SOP WDC-ANA-012<sup>24</sup>).

(2) Neat soman (GD) with a purity greater than 85 percent unless weapons-grade is desired<sup>23</sup>, and thickened with 5 percent (weight/volume) of Rohm and Haas Acryloid K125 poly(methyl methacrylate)<sup>24</sup>. This should provide thickened agent with a viscosity of  $1,000 \pm 100$  cSt at 20 °C. During preparation, batch-to-batch variability in viscosity may be greater than 10 percent. This large variability can be reduced by slowly adding the thickener over long periods of time. Complete solution of the polymer in GD is slow; therefore, mixing should continue until the measured viscosity is constant. The agent may be prepared with approximately 0.5 percent (weight/volume) of a suitable dye<sup>24</sup>.

(3) Neat HD with a purity greater than 85 percent, unless weapons-grade is desired<sup>23</sup>. The agent may be prepared with approximately 0.5 percent (weight/volume) of a suitable dye<sup>24</sup>.

(4) The minimum quantification level for HD is 50 µg; for GD is 2.5 µg; and for VX is 250 ng.

(5) Other approved contaminants (e.g., non-traditional agents (NTAs), toxic industrial chemicals (TICs), and toxic industrial materials (TIMs)) as specified in requirements documents and the TEMP.

b. Simulants to be used are specified in the test plan. Simulants may be prepared with a suitable dye or thickener.

#### 4.1.4.9 Test Item Preparation.

Sample locations will be marked to ensure samples are taken from the same area. The area markings must outline the total area. Sample location identifiers must be outside the marked area.

#### 4.1.4.10 Hood/Test Chamber Operation.

The test chamber will be operated using the procedures, controls, and SOPs used to approve the chamber and/or those approved for the agent. Some general technical data requirements for the test chamber are:

- a. The test chamber environmental conditions must be computer-monitored and data will be recorded at least every 15 minutes. The environmental conditions will include air temperature, RH, wind speed, test-item surface temperature, and pressure (chamber interior versus chamber exterior).
- b. The test item will be placed in the chamber and the chamber stabilized at the environmental conditions specified for the test. The test item will be conditioned until it has stabilized at  $30 \pm 2$  °C. Temperature and RH will be recorded continuously throughout the test.
- c. Before agent contamination, background swab and vapor samples must be taken from or near areas designated for contamination testing. The sampling and analysis must be tailored to detect materials that could interfere with the chemical analysis for the agent to be used.

#### 4.1.4.11 Agent/Simulant Application and Weathering.

- a. The mechanism for determining the actual amount of agent or simulant used to contaminate the test item is called a baseline contamination sample or dose confirmation sample. The data collected from these samples will provide confidence that the agent/simulant dissemination method performed well and also provide the value for initial contamination ( $C_i$ ) when calculating the decontamination efficacy(in percent) -  $(C_i - C_d)/C_i \times 100$ ; where  $C_d$  is the residual contamination after decontamination operations. Baseline samplers will be placed adjacent to the test item for actual contamination density assessment. The samplers will be contaminated before contamination of the test item.
- b. The selected areas of the test item will be contaminated with agent or simulant. The contaminant will be applied with a suitable dissemination device that has been calibrated and operated at the flow rate and pressure to achieve the drop size and contamination density specified in Paragraph 4.1.2.2.a and/or the test plan. Precision dissemination device (e.g., pipette) calibration should be current and compliant with the required performance specifications listed in the most current versions of the International Organization for Standardization (ISO) 8655 Parts 1 and 2<sup>25</sup> or American Society for Testing and Materials (ASTM) E 1154-89<sup>26</sup> for the volumes being delivered.
- c. Contamination density samplers will be removed and placed into a container with the appropriate type and quantity of solvent, sealed tightly, labeled, and transported to a chemical laboratory for analysis.

4.1.4.12 Decontamination of the Test Item.

a. Standard procedures, decontaminants, and equipment (see Paragraph 2 of FM 3-11.5<sup>27</sup> and Appendix B) and/or any test item-specific procedures, when supplied as part of the test-documentation package (e.g., technical manual), will be used. A summary of decontamination procedures is in Appendix C. All procedures used for conducting decontamination operations must include the correct ratio of decontaminant to agent established in decontaminant development to provide realistic comparison to operational testing.

b. A C/D cycle consists of the contamination event, the weathering period (representing travel time) and the decontamination procedure.

c. Decontamination of the test item will proceed when any required weather time is complete (e.g., 60 minutes).

d. Decontamination will begin with areas contaminated first and end with areas contaminated last.

e. If a test item is considered personal equipment (weapon, rucksack, etc.) or sensitive equipment (electronics, optics, etc.), then an immediate decontamination procedure may be required<sup>27</sup>. Personal equipment will be decontaminated using the M295 IEDK. There is no fielded decontamination system for sensitive equipment, but an alcohol-wetted cloth can be used<sup>27</sup>.

f. The thorough decontamination process includes the following steps:

(1) Equipment preparation, usually consisting of a HSW wash-down.

(2) Application of the decontaminant. Application of all currently fielded decontaminants requires brushing or scrubbing<sup>27</sup>.

(3) Decontaminant contact time (default is 30 minutes, but varies by decontaminant; some decontaminants may require continual application to remain wet throughout contact time)<sup>27</sup>.

(4) Post-decontamination clean water rinse to remove residual decontaminant and contaminant.

(5) Point detector monitoring for residual contamination.

g. All times for each phase of the procedure should be recorded, except the time to monitor for residual contamination.

h. Decontamination procedures must be performed as if the entire surface of the test item has been contaminated. The contaminated sampling areas will receive no more or no less

attention, time, or effort than uncontaminated areas. Appropriate time will be spent on angles and hard-to-work areas.

i. Decontamination procedures must be documented. Video documentation is recommended, but still photographs can be used.

#### 4.1.4.13 Post-Decontamination Sampling.

a. Vapor Sampling.

(1) When the surfaces of the sampling areas are no longer visibly wet after the clean water rinse, vapor sampling can begin. To determine residual vapor hazard, the decontaminated item must be placed in a temperature-controlled sampling box, or other enclosure of appropriate size to fit the item. For reproducible results, the box must have the following characteristics or features:

(a) It must have interior surfaces made of stainless steel or other material that is non-sorptive for agent/simulant.

(b) The box must generally fit the item with unobstructed airflow around the item but without excessive free air space that will allow pockets of agent/simulant vapor to remain for long periods of time.

(c) The box must be vented to allow it to be initially flushed, on command, with clean outside air (approximately one air exchange per minute for 4 minutes), and constructed to provide air (agent/simulant vapor) sampling ports.

(d) The interior of the box will be sampled for residual agent/simulant vapor before being used.

(2) Exact box shape and dimensions must be calculated when the size and shape of the test item are known.

(3) A minimum of two vapor samples (three samples are desirable) must be obtained for any time interval unless a NRT sampler is used. A vapor-sampling sequence must be specified in the test plan.

(4) Contaminated air will be aspirated through the SSTs (or other apparatus) at the appropriate rate and for the desired length of time (determined to minimize agent breakthrough) to trap agent vapor. Typically, MINICAMS are aspirated at a rate of 0.5 L/min; SSTs may be aspirated from 0.5 to 1.2 L/min; and glass impingers (bubblers) are aspirated at a rate of 1.0 L/min (SOPs WDC-WIN-006<sup>28</sup>, WDC-CL-044R<sup>29</sup>, and DP-0000-M-076<sup>30</sup>).

(5) Samples will be taken at appropriate intervals (as coordinated in the test plan) that total the duration of the mission time described in the CONOPS. Generally, more agent vapor will be given off during the first few hours of sampling and slowly decrease over time. Thus,

sampling intervals should be short in the beginning and longer sampling intervals later, when using cumulative sampling devices (bubblers or SSTs). This will avoid saturating any sampling device. A minimum of two SSTs must be obtained for any time interval (three samples are desirable), with the second sampler serving as a backup to the first sampler. A vapor-sampling sequence must be specified in the test plan. MINICAMS are NRT samplers, and the sample time setting selected will be determined to avoid saturating the detector.

b. Agent Contact Sampling.

(1) Sample locations on the test item will be where direct contact with the operator's skin or hands or prolonged contact with other clothed body parts is expected.

(2) Contact samplers (a thin disk of silicone rubber (1 millimeter (mm) thick) or other suitable material) will be prepared with a nominal size of 10 to 25 cm<sup>2</sup>. Any material used for a contact sampler must be free of powder. The contact sampler must be backed by aluminum foil (Figure 1) to prevent contamination of the weight, and then by a material such as sponge rubber to force contact with all surface irregularities. The assembled sampler will be placed on the selected area creating a pressure of 0.05 to 0.07 kilogram per centime squared (kg/cm<sup>2</sup>) (or 0.7 to 1.0 pounds per square inch (psi)) evenly applied for 15 minutes. For the 2-inch diameter sampler, this is equivalent to a 2-inch diameter cylindrical mass weighing 1 kg. Additional contact samplers can be sequentially placed on the same area, for selected intervals of time up to a total of 60 minutes.

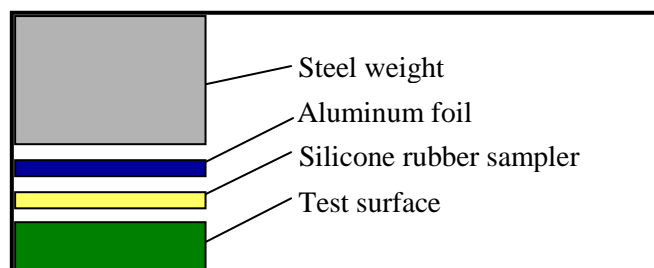


Figure 1. Diagram showing arrangement of the test surface, silicone rubber disk, and steel weight for residual chemical agent liquid sampling.

(3) After reaching the appropriate time interval, the contact sampler will be immediately removed. The sampler will be placed in a sample jar filled with the appropriate type and quantity of solvent; the jar will then be sealed and transported to a chemical laboratory for analysis.

(4) If possible, two contact samples will be taken from each area selected for contact sampling. The 0-hour sample shall be taken immediately after the decontamination rinse has dried. Samples shall be taken at intervals determined in the test plan as necessary for the specific CONOPS of the test item (e.g., how long a human might be expected to lean on, touch, hold the area sampled).

#### 4.1.4.14 Sample Analysis.

Sample analysis must use test instruments and methods that give precise and accurate values for the primary data parameters (SOPs WDC-ANA-004<sup>22</sup>, WDC-WIN-009<sup>31</sup>, WDC-ANA-032<sup>32</sup>, WDC-ANA-033<sup>33</sup>). Data from military chemical alarms, detectors, detector papers, and kits (that provide only qualitative yes/no answers) may be used to complement data obtained from more precise analytical instruments.

#### 4.1.4.15 Hardness Determination.

a. After completion of all decontamination and sampling procedures, all surfaces of the test item will be inspected for visible evidence of leakage and degradation caused by the agents, decontaminants, and decontaminating procedures. Other signs of material degradation may include corrosion, peeling paint, discoloration, brittleness of rubber components, hazing or yellowing of plastic components, etc. Any degradation must be described and documented with photographs.

b. The test item must be operated IAW the appropriate manual. ME functional performance characteristics must be measured and recorded. Each parameter must be measured at least twice. Any visible evidence of operational degradation will be recorded. The hardness and ME performance data collected must be comparable with the pretest values recorded (Paragraph 4.1.4.7.c).

c. Hardness data collection should be performed after each C/D cycle and 30 days (or the specified time interval in the test plan) after the first contamination. Hardness data must be sufficiently accurate and precise to define any degradation after each C/D cycle and the specified time period.

### 4.2 Biological Contamination Survivability.

#### 4.2.1 Objectives.

a. Decontaminability. Determine the ability of a system to be rapidly (less than 75 minutes<sup>9</sup>) and effectively decontaminated following exposure to an ABO or simulant. Measure the associated hazards with Warfighter use of equipment that has been contaminated with biological agent and decontaminated using standard and/or item-specific decontamination procedures.

b. Hardness. Determine the capability of a system to withstand the material damaging effects of biological agent and/or relevant decontaminations. Measure the degree of performance degradation in ME functions of military mission-critical materiel after biological agent C/D by standard and/or item-specific procedures.

#### 4.2.2 Criteria and Conditions.

##### 4.2.2.1 Criteria.

a. Materiel developed to perform ME functions shall be hardened to ensure that exposure to the specified CBR C/D cycles does not degrade the ME performance of the equipment more than 20 percent or that specified by the Combat Developer measured over a specified time or mission duration. The number of C/D cycles for biological survivability should consider pandemic events and the requirements imposed by the affected countries.

b. After decontamination, residual contamination levels for the equipment must constitute a negligible risk to unprotected users of the equipment<sup>10</sup>. In the determination of biological survivability, the following CBRCS test conditions apply.

##### 4.2.2.2 Conditions.

a. General Conditions. The time frame to start decontamination depends on the CDD, CPD, or test plan requirements. Standard field and/or item-specific decontaminants, equipment, and procedures will be used.

b. Detailed Conditions. If not already specified in the capabilities document, then the detailed conditions<sup>9</sup> for biological contamination survivability testing are as follows:

- (1) Chamber temperature:  $30 \pm 2$  °C.
- (2) RH: ambient  $\pm 2$  percent.
- (3) Test chamber air speed:  $< 1$  m/sec.
- (4) Exterior contamination density:  $1 \pm 0.5 \times 10^7$  CFU/m<sup>2</sup>.
- (5) Particle size: 1 to 5  $\mu$ m.

##### 4.2.2.3 Controls and Limitations.

The controls and limitations for the test items and sample analysis controls of biological agent contamination survivability testing are as follows:

##### a. Test Item Controls.

(1) Paint type, specifications, and application must comply with the system specification for the test item.

(2) Surface areas selected for sampling must be representative of the surface materials, texture, paint, and areas where the user will have direct contact.



b. Sample and Analysis Controls.

- (1) Swab control (unused swab).
- (2) Swab of a non-contaminated surface.
- (3) Diluent control.
- (4) Plate control.
- (5) A maximum of 18 hours between sample collection and culturing.

4.2.2.4 Data Required.

a. Test Chamber/Hood.

- (1) Temperature in °C.
- (2) RH in percent.
- (3) Wind speed (airflow around the test item) in m/sec.

b. Agent or Simulant.

- (1) Name, control number, and spore manufacturer.
- (2) Diluent used.
- (3) Percent solids.
- (4) Date prepared and/or reconstituted.
- (5) Date used.
- (6) CFU per mL.
- (7) Dissemination equipment used.
- (8) Quantity of agent/simulant suspension disseminated in mL.
- (9) Disseminator air pressure in psi.
- (10) Dissemination time in seconds.
- (11) Still color photographs and written description of each area contaminated.

(12) Contamination results for each sampling area (including background) before and after decontamination, expressed in CFU/sample.

c. Chamber air concentration level (calculated) immediately after dissemination, expressed in CFU/L of air.

d. Sample history with elapsed time to analysis in hours.

e. Elapsed time required to complete contamination, weathering time before decontamination, decontamination time, and time each sample will be taken in minutes.

f. Description of decontaminating solutions (i.e., formulation, active ingredients, and age), methods, equipment, lot number, and item-specific procedures used.

g. Description of test-item surface condition (pretest and post-test), materials of construction, paint type, and surface cleanliness (mud, grease, decontamination materials, and other). Photographs should be made of joints, crevices, textures, or other areas that may be difficult to decontaminate or allow liquid to penetrate.

h. Pretest and post-test ME functional performance characteristics used as the measure of the test item's mission performance before and after exposure to contaminants, decontaminants, and decontamination procedures.

i. Description of any safety issues.

#### 4.2.3 Methods and Procedures.

##### 4.2.3.1 Test Method Outline.

a. The agents/simulants are prepared for application. Paragraph 4.2.3.6 describes the details for this step of the test method.

b. Receipt inspection is conducted on the SUT to document as tested material conditions. Receipt inspection may include functional performance tests to establish baseline performance parameters (e.g., computer is operational, aircraft avionics are operational, etc.). Paragraph 4.2.3.7 describes the details of this step.

c. Test item is prepared for testing to include: sample location, identification, and documentation; marking of sample areas; etc., as described in Paragraph 4.2.3.8.

d. Disseminator Preparation. Paragraph 4.2.3.9 describes the details of this step.

e. Test Chamber Operations. Test chamber operation will be verified and environmental conditions for the test stabilized. Environmental conditions are monitored, the test item allowed to equilibrate with the ambient conditions, and background samples are taken before contamination. Paragraph 4.2.3.10 describes the details of this step.

- f. Agents/simulants are applied to the item under test IAW Paragraph 4.2.3.11.
- g. Post-contamination samples (contamination density verification) will be taken as described in Paragraph 4.2.3.12.
- h. Decontamination operations will be conducted on the item under test IAW Paragraph 4.2.3.13.
- i. Post-decontamination sampling will be conducted IAW Paragraph 4.2.3.14.
- j. Sample analysis will be performed IAW Paragraph 4.2.3.15.
- k. Hardness and post-decontamination functional performance measurements will be performed IAW Paragraph 4.2.3.16.
- l. Data presentation and hazard determination will be performed IAW Paragraph 6.3.

#### 4.2.3.2 Significance and Use.

- a. The sample data collected from this test allow a determination of biological spore hazards to unprotected personnel from decontaminated military materiel.
- b. The functional performance and/or material effects data collected allow a determination of the amount of physical or functional degradation of the system resulting from CBR contamination, decontamination procedures, and materials, to determine if there is a hardness issue.

#### 4.2.3.3 Interferences.

There are no interferences when the test method is conducted under laboratory-controlled conditions.

#### 4.2.3.4 Apparatus.

- a. The term apparatus will be used to cover the test fixture in which a test method may be conducted as well as the equipment used in conducting testing, sampling, and analytical instrumentation.
- b. Special vapor fixtures may be required because of the wide variety of systems that could be tested (e.g., night vision goggles, laptops, and a mockup of a larger item). Each fixture will have to be manufactured to fit the size of the test system. Each fixture should be capable of maintaining airflow around the test item, allowing operators to easily reach the test item for agent application, decontamination, and to perform sampling.

c. The instrumentation used in test method conduct, sampling for residual biological organisms, and the analytical equipment for sample analysis are found in Paragraphs 2.2 and 2.2.2.

#### 4.2.3.5 Hazards.

a. To address any hazards in working with the selected biological simulants, all safety protocols will be followed. Biological safety guidelines are found in DA PAM 385-69.

b. There are safety issues when testing with decontaminant chemicals that are hazardous (e.g., chlorine, hydrogen peroxide, etc.).

c. A test plan must be developed with a safety section identifying and addressing all safety concerns for each test conducted using these methods IAW AR 385-10. The safety section of the test plan will be coordinated with the test site's safety office.

#### 4.2.3.6 Biological Agent/Simulant Preparation.

a. The rationale for the selection and use of any biological simulants and the agent/simulant relationship must be documented in the test report.

b. Procedure controls and SOPs in effect at the time the chamber was approved for biological simulant testing must always be followed.

c. The biological organism (agent or simulant) used for testing will be characterized for proper particulate size profile (1 to 5  $\mu\text{m}$ ) and quality of spore preparation (greater than 95 percent spores).

d. As new decontaminants are developed, a live agent efficacy test must be conducted for screening purposes. In addition, it is possible that biological simulants currently used will not be appropriate and a new simulant must be selected. If a new simulant is selected, an agent/simulant relationship must be established. The rationale for simulant selection, agent/simulant relationship, and live-agent efficacy test results must be documented in the test report.

#### 4.2.3.7 Receipt Inspection and Functional Performance.

A receipt inspection and a pretest ME functional performance test, as described in Paragraph 4.1.4.7, will be performed if not previously performed as part of another test phase.

#### 4.2.3.8 Test-Item Preparation.

Sample locations must be marked to ensure samples are taken from the same area. For biological contamination survivability, three closely located 25-cm<sup>2</sup> sample areas for each location selected should be marked (Figure 2). At each sampling location, three samples will be collected: (1) background, (2) post-contamination, and (3) post-decontamination. Only the

boundary of the area should be marked; no markings should be made within the boundary. Sample location numbering or other designation should be marked outside the boundary.



Figure 2. Example of three closely located sampling areas with sampling sequence indicated.

#### 4.2.3.9 Disseminator Preparation.

The compressed-air dry-powder disseminator should be prepared to disperse the test organism containing particles in the 1 to 5  $\mu\text{m}$  size range. The appropriate operating time, air pressure, and concentration for the disseminator must be determined. The project biologist will determine exact disseminator air pressure, the duration of disseminator operation, and the number of CFUs required to meet the test-item contamination target of  $1 \times 10^7$  CFU/m<sup>2</sup> or  $2 \times 10^4$  CFU/25 cm<sup>2</sup>.

#### 4.2.3.10 Test Chamber Operations.

a. The test chamber will be brought to the environmental conditions specified for the test, and the test item will be placed into the chamber. The test item will be temperature-conditioned for a minimum of 2 hours. The temperature, RH, and wind speed will be recorded for the duration of the test.

b. Before proceeding to contamination of the test item, the first 25-cm<sup>2</sup> sampling areas at each sampling location must be swab sampled to determine the background contamination level and residual substances (decontaminant) that could interfere with sample assay.

#### 4.2.3.11 Agent/Simulant Application.

The dry powder disseminator will be used to apply the contaminant to the test item. One hour should be allotted for contamination to settle on the test item. After the settling, the chamber will be air-washed for one hour to reduce chamber contamination.

22 June 2012

#### 4.2.3.12 Contamination Density Sampling.

Immediately after the air-wash, the second 25-cm<sup>2</sup> area in each set will be swab sampled to determine the test-item contamination density.

#### 4.2.3.13 Decontamination of the Test Item.

a. Decontamination will begin immediately after contamination density sampling. Standard decontamination procedures, solutions, and equipment, or any test item-specific procedures furnished as part of the test documentation package will be used. Typically, a diluted bleach/water solution (1 gallon bleach mixed into 9 gallons water, which gives a 10 percent dilute bleach solution) is used.

b. Decontamination procedures must be performed as if the entire surface of the test item has been uniformly contaminated. Appropriate time should be spent on rough surfaces, joints, angles, and hard-to-clean areas.

c. All decontamination procedures, equipment, tools, and time used in the decontamination process, including item-specific procedures, must be recorded.

#### 4.2.3.14 Post-Decontamination Sampling.

When the test-item surface is dry following decontamination, the third 25-cm<sup>2</sup> area in each sampling location will be swab sampled to determine the residual contamination remaining on the test item.

#### 4.2.3.15 Sample Analysis.

Analysis of biological samples will be conducted IAW SOP WDL-WI-BIO-135<sup>34</sup>, Assay for Biological Simulants.

#### 4.2.3.16 Hardness Determination.

a. After biological decontamination is complete and the final set of swab samples has been taken, the test item will be visually inspected for evidence of degradation (e.g., corrosion, paint peeling, yellowing of plastics, etc.) caused by the test procedures. The test item will be operated, and all ME functional performance characteristics will be measured and recorded. Each parameter will be measured at least twice, depending on the inherent difficulty in reproducing a specific value. Post-C/D values will be compared with pretest values.

b. Any visible indication of operational degradation attributable to the biological C/D cycle(s) will be recorded.

c. After completion of the simulant or agent exposure, all surfaces of the item will be inspected for visible evidence of agent ingress or degradation caused by the agents. Degradation will be described and documented with video or photographs. The test item will be operated in

protective ensemble IAW the appropriate manual. ME functional performance characteristics will be measured and recorded. Each parameter will be measured at least twice. Test operators will be interviewed, and all evidence of operational degradation will be recorded. The hardness data collected must be comparable with the pretest values recorded (Paragraph 4.1.4.7.c).

#### 4.3 Radiological Contamination Survivability.

##### 4.3.1 Objectives.

a. Decontaminability. Determine the capability of a system to be rapidly (less than 75 minutes<sup>9</sup>) and effectively decontaminated following radioactive particulate exposure. Measure hazards associated with the Warfighters' use of equipment contaminated with radioactive particulate and decontaminated using standard and/or item-specific decontamination procedures.

NOTE: The activity considered in this test would result from residual radioactive particulate (fallout from a nuclear weapon or radiological dispersal device).

b. Hardness. Determine the capability of a system to withstand the material-damaging effects of radioactive particulate and/or relevant decontaminations. Measure the degree of performance degradation in ME functions of military mission-critical materiel after radioactive particulate C/D by standard and/or item-specific procedures.

##### 4.3.2 Criteria and Conditions.

###### 4.3.2.1 Criteria.

a. Decontaminability. The exterior surfaces of materiel developed to perform ME functions shall be designed so that radioactive contamination remaining on, or desorbed from, the surface following decontamination shall not result in more than a negligible risk to unprotected users of the item<sup>9</sup>. In the determination of risk level, the conditions listed in Paragraph 4.3.2.2 apply.

b. Hardness. Mission-critical equipment shall be hardened to ensure that exposure to radiological C/D cycles does not degrade the operational ME performance of the equipment more than 20 percent (or that specified by the Combat Developer) measured over a 30-day period<sup>9</sup> or as defined by the capabilities documents.

###### 4.3.2.2 Conditions.

###### a. General Conditions.

(1) The sequence of events for the decontamination process will be IAW the CDD or test plan requirements. Standard field and/or item-specific decontaminants, equipment, and procedures will be used, if available.

(2) Hazard levels will be calculated assuming an exposure time based on the CONOPS/concepts of employment (COEs), as specified by the Combat Developer.

b. Detailed Conditions<sup>9</sup>.

(1) Test chamber: temperature  $30 \pm 2$  °C.

(2) Ambient RH.

(3) Airflow (air circulation over the test item): < 1 m/sec.

(4) Radioactive fallout simulant. Short half-life isotope should have no more than 185 Gigabecquerel (GBq)/m<sup>2</sup> gamma activity.

(5) Fallout simulant particle size: 37 to 200 µm.

(6) Exterior target simulant contamination density: 4 g/m<sup>2</sup>.

(7) Sampling and counting controls: test-item background control, laboratory control, and sample-counting control.

(8) Surface areas selected for sampling must be representative of the surface materials, texture, paint, and the areas where the user will have contact with the item.

(9) Contamination weathering time before decontamination begins will be one hour after completion of contamination.

4.3.3 Controls.

Instruments must be properly calibrated.

4.3.4 Data Required.

a. Description of the test-item exterior materials of construction, paint type, and surface condition, including cleanliness (mud, grease, and other). Photographs of joints, crevices, textures, or other objects that may prove difficult to decontaminate.

b. Photograph and written description of each area selected for sampling.

c. Chamber: temperature in °C, RH in percent, and airflow in m/sec.

d. Complete simulant description, including (as applicable): source, lot number, particle count/g, and particle size range in µm.



- e. Disseminator used, operating air pressure in psi, dissemination time in seconds, mass of simulant disseminated (in grams), and calculated chamber-air contamination density in particles/L of air.
- f. Test-item background particle counts, test-item surface contamination density counts, test-item residual contamination (post decontamination) in particles/cm<sup>2</sup>, and QC values.
- g. All pertinent test event times and sample times in minutes.
- h. Description of decontamination equipment, methods, and solutions (if used), and any item-specific decontamination procedures and special devices used.
- i. Results of the visual inspection of the test-item surfaces after each C/D cycle.
- j. Pretest (baseline) and post-test ME functional performance data used to determine test-item hardness (degradation).
- k. Description of any safety issues.

#### 4.3.5 Methods and Procedures.

Simulants that are used must have documentation provided with the rationale for selection and particle size range.

##### 4.3.5.1 Test Method Outline.

- a. Receipt inspection and pretest ME function baseline measurements are conducted to document as-tested system interior conditions. These procedures are in Paragraph 4.3.5.6.
- b. Test item preparation procedures will include sample location, identification, documentation, and marking of sample areas (Paragraph 4.3.5.7).
- c. Background sampling procedures are in Paragraph 4.3.5.8.
- d. Test chamber operations procedures are in Paragraph 4.3.5.9.
- e. Simulant application procedures are in Paragraph 4.3.5.10.
- f. Post-contamination samples (contamination verification) taken are listed in Paragraph 4.3.5.11.
- g. Decontamination operations on the item under test are listed in Paragraph 4.3.5.12.
- h. Post-decontamination sampling procedures are in Paragraph 4.3.5.13.
- i. Sample analysis will be conducted IAW Paragraph 4.3.5.14.

22 June 2012

j. Hardness determination procedures are in Paragraph 4.3.5.15.

k. Data presentation procedures are in Paragraph 6.4.

#### 4.3.5.2 Significance and Use.

The sample data collected from this test allow a determination of radiological hazards from decontaminated military materiel to unprotected personnel.

#### 4.3.5.3 Interferences.

None.

#### 4.3.5.4 Apparatus.

Testing may be conducted in a variety of chambers which cannot be listed in this document.

#### 4.3.5.5 Hazards.

Short half-life isotopes are a personnel hazard and will require proper licensing, storage, monitoring, handling, and disposal procedures. Non-radioactive isotopes may require similar procedures, but should not present radiological hazards to personnel.

#### 4.3.5.6 Receipt Inspection.

A receipt inspection and pretest ME functional performance test, as described in Paragraph 4.1.4.7, will be performed if not previously performed as part of another test phase.

#### 4.3.5.7 Test-Item Preparation.

Sample area preparation will depend upon the type of simulant used:

a. For non-isotope sampling, three closely located 4-cm<sup>2</sup> sampling areas (see Figure 2) will be identified and marked. Only the boundary of the area should be marked; no markings should be made within the boundary. Sample location numbering or other designation should be marked outside the boundary.

b. When using non-radioactive isotopes or short half-life isotopes, sampling areas, especially where particulates may collect, such as crevices, rough surfaces, and corners, will be identified and marked. These same areas may be used for background, post-contamination, and post-decontamination sampling.

#### 4.3.5.8 Background Samples.

a. For non-isotope counting only, before contamination, the first of the three collocated sampling areas will be sampled to determine if a background contamination level exists that

could interfere with sample analysis. Sample collection methodology must be described in the test plan.

b. For non-radioactive or short half-life isotopes, a background sample will be taken at each sample location.

c. The short half-life isotope sampling will be conducted using a quantifying radioactivity detector. The detector capabilities and limitations will be described in the test plan.

#### 4.3.5.9 Test Chamber Operation.

The test chamber will be brought to the environmental conditions specified for the test, and the test item will be placed into the chamber. The test item will be temperature conditioned for a minimum of two hours.

#### 4.3.5.10 Simulant Application.

a. The disseminating apparatus will be calibrated for the simulant application.

b. The simulant will be disseminated onto the test item(s).

c. One hour will be allowed for contaminant settling.

#### 4.3.5.11 Contamination Density Sampling.

a. For non-isotope counting only, after contamination, the second of the three collocated sampling areas will be sampled following the procedure in Paragraph 4.3.5.8.

b. For non-radioactive or short half-life isotopes, a post-contamination sample will be taken at each sample location.

#### 4.3.5.12 Decontamination Procedures.

a. Decontamination will begin immediately after contamination density sampling. Standard decontamination procedures, solutions, and equipment or any test item-specific procedures, furnished as part of the test documentation package, will be used.

b. Decontamination procedures will be performed over the entire surface of the test item. Appropriate time should be spent on rough surfaces, joints, angles, and hard-to-work areas.

#### 4.3.5.13 Post-Decontamination Sampling.

a. For non-isotope counting only, after contamination, the third of the three collocated sampling areas will be sampled following the procedure in Paragraph 4.3.5.8.

b. For non-radioactive or short half-life isotopes, a post-contamination sample will be taken at each sample location.

#### 4.3.5.14 Sample Analysis.

Non-radioactive isotopes will be submitted for analysis using appropriate techniques and instrumentation that will be described in the test plan. Any rationale for selection of the analytical methodology will be included.

#### 4.3.5.15 Hardness Determination.

a. After radiological decontamination is complete and the final set of samples has been taken, the test item will be visually inspected for evidence of degradation (e.g., corrosion, paint peeling, yellowing of plastics, etc.) caused by the test procedures. The test item will be operated, measured, and all ME functional performance characteristics will be recorded. Each parameter will be measured at least twice, depending on the inherent difficulty in reproducing a specific value. The post-C/D values will be compared with pretest values.

b. Any indications of operational degradation attributable to the radiological C/D cycle will be recorded.

### 4.4 Long-Term CBR Hardness.

#### 4.4.1 Objective.

Determine the long-term (as specified in the capabilities documents, but greater than 30 days<sup>9</sup>) affects of CBR contamination and CBR decontamination procedures.

#### 4.4.2 Criterion.

None. There is no criterion for hardness determination for a time period greater than 30 days.

#### 4.4.3 Long-Term Hardness Determination.

At the conclusion of the long-term period, the test item will be visually inspected for evidence of degradation caused by the test procedures. The test item will be operated, and all ME functional performance characteristics will be measured and recorded. Each parameter will be measured at least twice, depending on the inherent difficulty in reproducing a specific value. The post-test values will be compared with pretest values. Procedures and data required are the same as those described for chemical hardness in Paragraph 4.1.4.15.

#### 4.5 CBR Compatibility.

##### 4.5.1 Objective.

Determine the capability of a system to be operated, maintained, and re-supplied by persons wearing a full protective ensemble (MOPP IV). Measure the degree of degradation in ME Warfighter tasks pertaining to operating a piece of equipment in MOPP IV or equivalent CBR-protective ensemble.

##### 4.5.2 Criteria.

The combination of equipment and CBR protection shall permit performance of ME operations, communications, maintenance, resupply, and decontamination tasks by trained and acclimatized troops over a typical mission profile in a contaminated environment not to exceed 12 hours:

- a. In meteorological conditions of areas of intended use.
- b. With no degradation, excluding heat stress, degradation of crew performance of ME tasks will be no greater than 15 percent below levels specified for these tasks when accomplished in a non-NBC environment<sup>9</sup>.

##### 4.5.3 Controls and Limitations.

- a. The protective gloves used as part of the laboratory protective equipment are very similar to fielded gloves that are part of the CBR protective equipment or MOPP IV. The test operator will record any compatibility issues based on loss of tactility or ability to manipulate buttons, knobs, or dials in the use or operation of the test item.
- b. Testing laboratories cannot truly replicate the meteorological conditions of operational environments.

##### 4.5.4 Data Required.

- a. A listing of ME tasks identified by the Combat Developer for the equipment undergoing CBR compatibility testing must indicate how each task is to be measured and whether the function is to be classified as an attribute (GO, NO-GO) or a variable measured over a specified range.
- b. Baseline ME performance characteristics for the equipment must be determined.
- c. ME tasks and equipment performance must be measured with operators attired with and without laboratory protective equipment.
- d. Out-of-tolerance performance, breakdowns, or other anomalous performance occurring during compatibility tests will be documented.

#### 4.5.5 Methods and Procedures.

##### 4.5.5.1 Test Method Outline.

- a. Each test item operation will be conducted at least once with the operator dressed in normal clothing (Paragraph 4.5.5.7.b).
- b. Each test item operation will be conducted at least once with the operator dressed in laboratory protective clothing (Paragraph 4.5.5.7.b).
- c. The time required to conduct the operation or each distinct portion of a total operation (Paragraph 4.5.5.7.c) will be measured.
- d. Compatibility degradation will be determined and the data presented as shown in Paragraph 6.6.

##### 4.5.5.2 Significance and Use.

This testing will acquire data that will allow a determination of the impact of wearing MOPP IV ensemble on the ability of Warfighters to perform operations and/or maintenance functions on the SUT.

##### 4.5.5.3 Interferences.

None.

##### 4.5.5.4 Apparatus.

Testing can be conducted in a variety of chambers, which cannot be listed in this document.

##### 4.5.5.5 Hazards.

None.

##### 4.5.5.6 Test Planning and Preparation.

- a. Only limited compatibility testing can be conducted in a laboratory. The majority of this testing and data collection will occur during operational testing.
- b. A scenario specifying functions and operations to be evaluated during a typical mission profile must be prepared. It will include a list of the test item to be used and the sequence of tasks to be measured. The exact measurements to be taken, the sequence in which they are taken, and the instrument or measuring device used will be clearly specified. The scenario must ensure that all functions or tasks identified as essential are executed and evaluated.

c. A sufficient number of rehearsals must be performed to ensure that equipment familiarization is not a factor in the compatibility determination.

#### 4.5.5.7 Test Conduct.

a. Equipment to be tested will be operated and maintained in strict compliance with operating manuals, instructions, and SOPs. When performing maintenance tasks, only tools and repair procedures specified for the equipment will be used.

b. The scenario must be performed once in normal clothing and another time in laboratory protective clothing.

c. The time required to conduct the operation or each distinct task of a total operation will be measured.

### 5. DATA REQUIRED.

The data requirements for each of the specific subtests are identified along with each of the subtests described in Paragraph 4.

### 6. PRESENTATION OF DATA.

Test information should be placed in the Automated Test Incident Reporting System (ATIRS) or other data collection system format for review by all interested parties. Test-item failures will be scored by the information included in the ATIRS and the FD/SC.

#### 6.1 Receipt Inspection.

Decontaminability data must include a description of the as-received test item or mock-up, identifying any damage and specific conditions of the surface to be exposed to agents, biological spores, or radiological fallout simulant. Receipt inspection photographs are important. Differences between the mock-up and the test item must be described. Receipt inspection photographs of exterior materials, construction, paint, cleanliness, joints, and crevices will be required.

a. All data on item damage, missing components, surface condition, other discrepancies, and test-item history must be reported. Results will be summarized and presented in tabular form, including surface cleaning or maintenance performed, and emphasizing deviations from developer specifications.

b. Mock-up receipt-inspection data will be reported, noting differences between the mock-up and the test item.

c. Data pertaining to surface materials and their finishes will be reported in a form that can be compared with pretest and post-test hardness functional performance data.

## 6.2 Chemical Contamination Survivability.

a. Chemical decontaminability will be determined by comparing post-test residual agent with established criteria for each agent (Paragraph 4.1.2.1). The item will be considered chemical agent decontaminable if residual vapor and contact hazard are reduced to levels at or below the established decontamination criteria<sup>9</sup>.

b. Each sampling area, including the location, material of construction, surface geometry, and surface texture, will be described. Each description will cite the contaminant, contamination procedure, decontaminant, and the decontamination procedures used, including item-specific procedures and time expended on each procedure. A description of pertinent information will be included in the test report. Decontamination operation video coverage and/or still photographs will be made.

c. A summary and table of the hood/chamber conditions during the test period will be created. The agent physical properties, agent contamination density, and the drop size for each item or sampling area, will be presented, and deviations from specified values will be identified.

d. The quantity of agent recovered from each agent contact sampler, identified by the location and time at which the sample was taken, will be tabulated.

e. A comparison must be made based on the area of operator skin that would contact the location sampled to determine if a hazard exists. The resulting data and hazard criterion will be represented in table format.

f. The average concentration of agent vapor recovered from each test-item sampling location (component, if used) identified by time period should be represented in table format.

g. The agent vapor mass will be run through the downwind hazard prediction model<sup>13</sup> and the calculated dosages will be compared with the DA approved NBCCS criteria for Army materiel<sup>9</sup>.

(1) No simple procedure exists for determining vapor hazard to the test-item operator(s). The credible dosage received is a function of agent desorption from the decontaminated test item, worst-case or other selected scenarios that have almost unlimited variables, and the established “no effects” criteria

(2) One newly developed approach<sup>14</sup> would be to calculate toxic load from the agent vapor dosages measured from a test item. This approach allows the toxic load calculations to be transferred to exposure scenarios on a case-by-case basis, depending on the test item and its expected use in the field.

h. If an item fails the decontaminability criterion, an attempt should be made to identify the material composition responsible for the failure. Failure of the decontaminability criterion may necessitate the testing of individual materials.



i. When three or more identical test items are used in any C/D cycle, statistical analyses conducted on all test results will be presented.

j. All ME function performance data, identified by test-cycle number, agent, and decontaminant, will be summarized and tabulated.

k. ME function performance data for each C/D cycle will be compared with the receipt inspection performance data. The ME performance data and operator interview data will be used to determine whether more than 20 percent degradation in item performance (or that specified by the combat developer) has occurred (Paragraph 4.1.2.1 a). Significant results will be highlighted and discussed.

l. A sample analysis table of chemical agent and decontaminant effects is provided as Table 1.

TABLE 1. SAMPLE DATA FORM.

ANALYSIS OF CHEMICAL AGENT AND DECONTAMINATION EFFECTS ON THE WIDGET X			
Component	Material	Agent Effects	Decontaminant Effects
Plate	Sheet titanium, grade 2	Not expected to have any effect.	Not expected to have any effect.
Foam element no. 1	Cushioning material, packing closed cell foam planks	Expected to absorb and desorb chemical agents and trap nuclear and biological agents. May disintegrate when exposed to chemical agents.	May disintegrate when exposed to decontaminants.
Sealant	Manganese dioxide cured polysulfide compound	There is no data in the CBME database for manganese dioxide. Polysulfide is expected to absorb and desorb CWAs.	There is no data in the CBME database for manganese dioxide.
Sealant	Aerospace Sealant, part no. ABCD-12	Will sequester CWAs and may pose an off-gassing hazard with agent vapors if directly contaminated with CWAs.	May cause hardening or swelling of the sealant, which may weaken the seal.
Rivet	Stainless steel	Not expected to have any effect.	Not expected to have any effect.

### 6.3 Biological Contamination Survivability.

a. Each sampling area will be described (inclusion of photographs is encouraged), including the location, materials of construction, surface geometry, and surface texture. The decontaminant, decontamination time, and decontamination procedures used, including item-specific procedures furnished by the Materiel Developer, will be recorded.

b. The chamber conditions during the test period will be summarized and described. A description of the test organism physical property data and aerosol disseminator operating data will be recorded. Any deviations from target values will be identified and explained.

c. For each material/location, the following will be summarized: the CFU recovered from the control samples, the chamber air-contamination level, the test-item contamination level, and the residual sample level after decontamination, including any residual sample values obtained after subsequent decontaminations.

d. The decontamination reduction ratio achieved by the decontamination process (the item challenge contamination level divided by the residual contamination level) for each sampling location will be calculated. The CFUs (spores that have become viable cells) that are sampled after decontamination will be divided by the number of CFUs sampled after contamination of the test item. This reduction ratio will be expressed as the log reduction. The reduction ratio and the raw challenge and residual data will be presented in tabular form. The item will successfully meet the criterion<sup>9</sup> for biological decontaminability and be considered decontaminable for biological agent if the contamination of the system has a six or greater log reduction.

e. The biological hardness determination will be the same as for chemical hardness and the procedures are the same as those described in Paragraph 4.1.4.15.

#### 6.4 Radiological Contamination Survivability.

a. In the test report, each sampling area will be described (photographs are preferable), including the location, materials of construction, surface geometry, and surface texture. The decontaminant, decontamination time, and the decontamination procedures used, including item-specific procedures furnished by the Materiel Developer, will be recorded.

b. The chamber environmental conditions will be presented in a table.

c. Complete simulant description will be recorded.

d. Disseminator operating data will be recorded. Any deviations from target values will be identified and explained.

e. The data for each sample location (background, post-contamination, and post-decontamination) will be presented in tabular form.

f. For the non-isotope or non-radioactive isotope data, the reduction ratio achieved (the item challenge contamination level divided by the residual contamination level) will be calculated and included in the data table. If the reduction ratio is 50 percent or greater, the system will be considered decontaminable.

g. For the short half-life isotope data, the calculated decontamination values will be compared with the CS criterion and included in the data table. The item will be considered decontaminable for radiological particles if the contamination is reduced to levels below the established criterion<sup>9</sup>.

#### 6.5 Long-Term CBR Hardness.

Hardness data will be presented in a format to show direct comparison of pretest and post-test exposure ME function performance of the test item. Any visible effects will be recorded. The long-term hardness determination will be performed the same as chemical hardness as described in Paragraph 4.1.4.15.

#### 6.6 CBR Compatibility.

a. Test-item performance data will be summarized and presented in tabular form. The time taken to perform the operation with protective gear will be subtracted from the time taken to perform the operation without the protective gear. The differences in performance attributable to type of clothing worn will be highlighted.

b. Any operational difficulties attributed to the wearing of laboratory protective clothing by operators will be recorded.

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## APPENDIX A. EXPLANATION OF TERMS.

Capability Document. A document that captures the capabilities specific to the initial concept, development, or production of a program.

Capability Development Document (CDD). A document that captures the information necessary to develop a proposed program(s), normally using an evolutionary acquisition strategy. The CDD outlines an affordable increment of militarily useful, logistically supportable, and technically mature capability.

Capability Production Document (CPD). A document that addresses the production elements specific to a single increment of an acquisition program.

Chemical, Biological, and Radiological (CBR) Compatibility. The capability of a system to be operated, maintained, and re-supplied by persons wearing a full complement of individual protective equipment, in all climates for which the system is designed and for the period specified in the Capability Development Document (CDD) or Capability Production Document (CPD).

CBR Decontaminability. The ability of a system to be rapidly and effectively decontaminated to reduce the hazard to personnel operating, maintaining, and resupplying it.

CBR Decontamination. The process of making material safe by absorbing, destroying, neutralizing, rendering harmless, or removing chemical or biological agents and radiological contamination.

CBR Environment. The environment created by chemical, biological, or radiological contamination.

CBR Hardness. The capability of material to withstand the material-damaging effects of CB contamination and relevant decontaminations.

Chemical, Biological, Radiological (CBR) Contamination Survivability (CBRCS). The capability of a system to withstand CBR contaminated environments, decontaminants, and decontamination processes, without losing the ability to accomplish the assigned mission. A CBR-contaminated survivable system is hardened against CB agent(s) or radiological contamination and decontaminants. It can be decontaminated, and is compatible with individual protective equipment. CBRCS may be accomplished by hardening, timely re-supply, redundancy, mitigation techniques (to include operational techniques), or a combination thereof. The elements of CBRCS covered by this TOP are compatibility, decontaminability, and hardness.

## APPENDIX A. EXPLANATION OF TERMS.

Chemical, Biological, Radiological, and Nuclear (CBRN) Survivability. The capability of a system to avoid, withstand, or operate during and/or after exposure to a CBR environment (and relevant decontamination) and a nuclear environment, without losing the ability to accomplish the assigned mission. CBRN survivability is divided into CBR survivability, which is concerned with CBR contamination to include fallout, and nuclear survivability, which covers initial nuclear weapon effects including Electromagnetic Pulse (EMP).

Combat Developer. A category of sponsor responsible for drafting, staffing, and revising capabilities documents.

Initial Capabilities Document (ICD). Documents the need for a materiel approach or an approach that is a combination of materiel and non-materiel to satisfy a specific capability gap(s). It defines the capability gap(s) in terms of the functional area, the relevant range of military operations, desired effects, time, and doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF) and policy implications and constraints. The ICD summarizes the results of the DOTMLPF analysis and approaches (materiel and non-materiel) that may deliver the required capability. The outcome of an ICD could be one or more joint DOTMLPF change recommendations or CDDs.

Material Developer. The organization responsible for research, development, and acquisition of material systems in response to capabilities documents.

Mission-Critical System. A system whose operational effectiveness and operational suitability are essential to successful mission completion or to aggregate residual combat capability. If this system fails, the mission will not likely be completed. Such a system can be an auxiliary or supporting system, as well as a primary mission system.

Neutron-Induced Gamma Activity. The radioactivity of elements, typically in soil, induced by neutrons produced by a nuclear burst. The induced radioactivity produces gamma and beta radiation.

Sponsor. The organization responsible for drafting, staffing, and revising capabilities documents. For this document, sponsors include Combat Developers.

System Threat Assessment. A predecessor document that is used to summarize in a CDD the projected threat environment and the specific threat capabilities to be countered. The summary includes the nature of the threat, threat tactics, and projected threat capabilities (both lethal and nonlethal) over time.

## APPENDIX B. TEST EQUIPMENT.

Thermocouple.

Humidity probe.

Anemometer.

Still color camera.

Video camera.

Bubblers, MINICAMS (a miniature, automatic, continuous air-monitoring system), solid sorbent tubes (SSTs), or equivalent.

Gas chromatograph (GC), high-performance liquid chromatograph (HPLC), liquid chromatograph (LC), spectrophotometer, or equivalent.

Silicone rubber, latex dental dam or equivalent.

Compressed air dry powder disseminator.

Air-driven liquid-slurry disseminator.

Microscopes, automatic colony counters, or equivalent, swabs or wipes placed in growth medium.

Radioactivity detector.

Stop watches or equivalent.

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## APPENDIX C. SUMMARY OF DECONTAMINATION SYSTEM PROCEDURES.

The following decontamination system procedures are a summary from FM 3-11.5<sup>25</sup> for Army and Marine Corps. The M291 skin decontamination kit (SDK) is not described in this appendix because it is only fielded for use on skin, and this is not pertinent to chemical, biological, radiological contamination survivability (CBRCS).

<u>Decontamination System</u>	<u>General Procedure for Use</u>	<u>General Equipment Procedures</u>
M295 Individual Equipment Decontamination Kit (IEDK)	The mitt is to be placed on the hand and patted on the surface of the equipment being decontaminated. Scrubbing motions should not be used because it may clog the mitt material and prevent distribution of the sorbent powder. The powder should be removed from the equipment by brushing, wiping, or high-pressure air.	This kit is only issued for use on a Warfighter's individual equipment. The sorbent powder in this kit will absorb all liquids, including lubricants. Any lubricated personal equipment (e.g., rifle) will need to be cleaned and lubricated before use. This kit is for immediate decontamination.
M100 Sorbent Decontamination System	When the kit is opened, there are two packets with sorbent powder and two mitts included. A sorbent powder packet should be carefully opened, and the contents placed onto the mitt palm. The mitt is then used to apply sorbent powder onto equipment using patting or scrubbing motions. Additional powder is applied to the mitt as necessary. The second packet may be necessary for continued decontamination efforts.	This system is issued to vehicles and other systems, not to personnel. The sorbent powder in this kit will absorb all liquids including, lubricants. Any lubricated equipment will need to be cleaned and lubricated before use. This system is to be used for operational decontamination.
M17	This system is used to apply hot soapy water (HSW) and/or a high-pressure clean water rinse.	This system is most likely to be used at a thorough decontamination site.

APPENDIX C. SUMMARY OF DECONTAMINATION SYSTEM PROCEDURES.

<u>Decontamination System</u>	<u>General Procedure for Use</u>	<u>General Equipment Procedures</u>
M12	<p>This system is used to apply low-pressure high-volume water for equipment prerinse, supertropical bleach (STB) slurry, HSW and high-test hypochlorite (HTH) solution. The low-pressure high-volume prerinse will be performed before decontaminant application. The STB slurry or HTH solution will be applied to vehicles or equipment and an individual with a scrubbing brush will follow closely so that the slurry/solution is not allowed to dry. This operation is conducted on both sides of a vehicle simultaneously, using two M12s. If the air temperature is too high, additional applications of the slurry/solution may need to be applied to maintain decontaminant/agent contact.</p>	<p>An M12 is only used at a thorough decontamination site. Before the decontamination procedures begin, each equipment system that goes through thorough decontamination may require components to be removed and/or components (e.g., lenses) protected (covered) from the effects of decontaminants. After decontamination has been verified, components that have been removed will most likely need to be replaced with new components. Protected components must be separately decontaminated with the appropriate decontamination for that component.</p>
M26 Joint Service Transportable Decontamination System- Small Scale (JSTDS-SS)	<p>This system will be used to apply water and HSW to perform operational decontamination missions and support thorough decontamination operations. It may also be used to support clearance decontamination missions, limited facility decontamination, and/or terrain decontamination.</p>	<p>This system is most likely to be used at the site of a system's operational decontamination.</p>

#### APPENDIX D. MATERIAL PROPERTIES MATRIX AND DATA TEMPLATE.

The Material Properties Matrix provides a useful tool for Program Managers, testers, and database developers to acquire the information needed to ensure that defense systems are survivable to the effects of CBR contamination and the decontamination process. This matrix details the critical properties of materiel that program managers and testers should test to determine if mission-critical systems are survivable in a CBR environment by measuring any significant degradation to these critical properties. While survivability determinations are not limited to the materials and properties listed in this matrix, it provides a minimum framework for data that Program Managers and testers should provide to the CBME database so that appropriate survivable materials can be selected during the design of new systems or system upgrades.

APPENDIX D. MATERIAL PROPERTIES MATRIX AND DATA TEMPLATE.

TABLE D-1. MATERIALS AND PROPERTIES OF INTEREST

Properties			Metals	Laminates	Adhesives/Sealants/ Joints (Including Welds)	Coatings	Potting Compounds	Optical Materials (Metal Oxides, Plastics, etc.)	Elastomers	Plastics	Composite Materials	Petroleum, Oil, and Lubricants (POL)	Textiles	Ceramics
Agent Effects	1	Agent absorption ( $\mu\text{g}/\text{cm}^2$ absorbed per time period) and agent desorption ( $\mu\text{g}/\text{cm}^2$ desorbed per time period)		X	X	X	X	X	X	X	X		X	X
	2	Permeation (time to breakthrough of agent)/penetration of vapors and liquids			X	X	X		X	X			X	X
	3	Weight change	X	X	X	X	X	X	X	X	X		X	X
	4	Density	X	X	X	X	X				X			X
	5	Off gassing (vapor)	X	X	X	X	X	X	X	X	X		X	X
	6	Contact hazard (liquid)	X	X	X	X	X	X	X	X	X		X	X
Mechanical Properties	7	Elastic modules	X	X	X				X	X	X			
	8	Tensile Properties (yield strength, ductility)	X	X	X		X	X	X	X	X		X	X
	9	Hydrogen embrittlement	X	X	X	X								
	10	Ultimate strength for tension (flexural)		X	X									
	11	Compressive strength	X	X	X			X		X	X			X
	12	Shear strength	X	X	X		X			X	X			X
	13	Fracture toughness (compression, bending, tensile, shear, impact)	X	X	X	X	X	X	X	X	X			X
	14	Hardness (indentation, durometer, scratch resistance)	X	X	X	X	X	X	X	X	X		X	X
	15	Resilience (capacity to absorb energy elastically)	X	X					X	X	X			X
	16	Fatigue strength (includes adhesives for structural bonds)	X	X	X					X	X			X

APPENDIX D. MATERIAL PROPERTIES MATRIX AND DATA TEMPLATE.

TABLE D-1. CONT'D

Properties			Metals	Laminates	Adhesives/Sealants/ Joints (Including Welds)	Coatings	Potting Compounds	Optical Materials (Metal Oxides, Plastics, etc.)	Elastomers	Plastics	Composite Materials	Petroleum, Oil, and Lubricants (POL)	Textiles	Ceramics
Mechanical Properties	17	Puncture resistance							X	X	X		X	X
	18	Creep (rupture) strength	X	X	X					X	X			
	19	Compressive spring constant							X		X			
	20	Bond strength	X	X	X						X			X
POL Properties	21	Thermal stability										X		
	22	Chemical compatibility										X		
	23	Lubricity										X		
	24	Solubility										X		
	25	Melting point/boiling point										X		
	26	Viscosity										X		
Physical Properties	27	Dimensional change	X	X	X	X	X	X	X	X	X		X	X
	28	Color change (discoloration, surface finish)	X	X	X	X	X	X	X	X	X		X	X
	29	Optical clarity/distortion (haze, transmittance, reflectance)				X		X		X				X
	30	Crazing, stress, corrosion, cracking	X	X	X	X	X	X		X				X
	31	Acoustic dampening		X		X					X			
	32	Glass transition temperature		X	X			X	X	X	X			X
	33	Rubber property-effects of liquids							X					
	34	Peel/lap shear strength change		X	X	X					X			
	35	Adhesion (loss of), blistering, spalling		X	X	X	X				X			X
	36	Corrosion rate	X	X	X						X			X

APPENDIX D. MATERIAL PROPERTIES MATRIX AND DATA TEMPLATE.

TABLE D-1. CONT'D

Properties			Metals	Laminates	Adhesives/Sealants/ Joints (Including Welds)	Coatings	Potting Compounds	Optical Materials (Metal Oxides, Plastics, etc.)	Elastomers	Plastics	Composite Materials	Petroleum, Oil, and Lubricants (POL)	Textiles	Ceramics
Thermal Properties	37	Thermal conductivity	X	X	X	X	X			X	X			X
	38	Flame resistance		X	X			X	X	X	X		X	X
	39	Flash point/ignition temperature			X	X						X	X	
Electrical Properties	40	Insulative properties (including dissipation factor)		X		X	X		X	X	X			X
	41	Dielectric constant		X	X	X	X	X	X	X	X			X
	42	Electrical conductivity	X	X	X	X	X		X	X	X			
	43	Impedance	X	X	X	X	X		X	X	X			
	44	Relative permittivity		X		X				X	X			X
	45	Polarizability (effect on radar signals)		X		X				X	X			X

## APPENDIX E. ABBREVIATIONS.

μL	microliter
ABO	agent of biological origin
AD No.	accession number
AEC	U.S. Army Evaluation Center
AFOTEC	Air Force Operational Test and Evaluation Center
APG	Aberdeen Proving Ground
AR	Army Regulation
ASTM	American Society for Testing and Materials
AT&L	acquisition, technology, and logistics
ATEC	U.S. Army Test and Evaluation Command
ATIRS	Automated Test Incident Reporting System
ATP	Allied Tactical Publication
BWA	biological warfare agent
C	Celsius
C/D	contamination/decontamination
CAPAT	Commodity Area Process Action Team
CB	chemical and biological
CBCS	chemical biological contamination survivability
CBME	chemical and biological materials effects
CBR	chemical, biological, and radiological
CBRCS	CBR contamination survivability
CBRN	chemical, biological, radiological, and nuclear
CBRNIAC	Chemical, Biological, Radiological, and Nuclear Information Analysis Center
CDD	Capability Development Document
C <sub>et</sub>	effective concentration of agent vapor desorbed over time
CFU	colony forming unit
cm	centimeter
COE	concept of employment
COMOPTEVFOR	Commander operational Test and Evaluation Force
CONOPS	concept of operations
CPD	Capability Production Document
cSt	centistoke
CWA	chemical warfare agent

## APPENDIX E. ABBREVIATIONS.

DA	Department of the Army
DoD	Department of Defense
DoDI	Department of Defense Instruction
DOTMLPF	doctrine, organization, training, materiel, leadership and education, personnel and facilities
DPG	U.S. Army Dugway Proving Ground
DTIC	Defense Technical Information Center
DUSA TE	Deputy Under Secretary of the Army, Test and Evaluation
EA	environmental assessment
ECBC	Edgewood Chemical Biological Center
EMP	electromagnetic pulse
FD/SC	Failure Definition/Scoring Criteria
FM	Field Manual
GAO	U.S. Government Accountability Office
GBq	Gigabecquerel
GC	gas chromatograph
GD	soman
HD	distilled mustard
HPLC	high-performance liquid chromatography
HSW	hot soapy water
HTH	high-test hypochlorite
IAW	in accordance with
ICD	Initial Capabilities Document
IEDK	Individual Equipment Decontamination Kit
ISO	International Organization for Standardization
JPEO-CBD	Joint Program Executive Office for Chemical Biological Defense
JPM	Joint Project Manager
JRO-CBRND	Joint Requirements Office for Chemical, Biological, Radiological, and Nuclear Defense
JSTDs-SS	Joint Service Transportable Decontamination System-Small Scale
JSTO	Joint Service and Technology Office
kg	kilogram
LC	liquid chromatograph



## APPENDIX E. ABBREVIATIONS.

m/sec	meters per second
MCOTEA	Marine Corps Operational Test and Evaluation Activity
ME	mission essential
MIL-STD	Military Standard
MINICAMS	a miniature, automatic, continuous air-monitoring system
mm	millimeter
MMD	mass median diameter
MOPP IV	mission-oriented protective posture, level IV
MS	mass spectrometry
NATO	North Atlantic Treaty Organization
NBC	nuclear, biological, and chemical
NBCCS	NBC contamination survivability
NDAA	National Defense Authorization Act
NEPA	National Environmental Policy Act
NIGA	neutron-induced gamma activity
NRT	near-real time
NTA	non-traditional agent
OEP	OTA Evaluation Plan
OTA	Operational Test Agency
PAM	Pamphlet
PL	Public Law
POL	petroleum, oil, and lubricants
psi	pounds per square inch
QA	quality assurance
QC	quality control
QSTAG	Quadripartite Standardization Agreement
R <sup>2</sup>	correlation value
RDD	radiological dispersal device
REC	record of environmental consideration
RH	relative humidity
SDK	skin decontamination kit
SOP	Standing Operating Procedure
SST	solid sorbent tube
STB	supertropical bleach
SUT	system under test

APPENDIX E. ABBREVIATIONS.

T&E	Test & Evaluation
TECMIPT	T&E Capabilities and Methodologies Integrated Process Team
TEMP	Test and Evaluation Master Plan
TGD	thickened soman
TIC	toxic industrial chemical
TIM	toxic industrial material
TIR	test incident report
TOP	Test Operations Procedure
TSARC	Test Schedule and Review Committee
U.S.	United States
USANCA	U.S. Army Nuclear and Combating Weapons of Mass Destruction Agency
USD	Under-Secretary of Defense
VDLS	VISION Digital Library System
VISION	Versatile Information Systems Integrated Online Nationwide
VX	persistent nerve agent

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15. AR 385-10, Safety: The Army Safety Program, 4 October 2011.
16. DA PAM 385-61, Safety; Toxic Chemical Agent Safety Standards, 17 December 2008.
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20. TOP 08-2-500, Receipt Inspection of Chemical and Biological (CB) Materiel, 1 July 1984.
21. U.S. Army DPG, SOP DP-0000-M-073\*\*, Preparation and Verification Procedures for First Dilution, Stock A and Working Solutions, Revision 11, 6 April 2009.
22. U.S. Army DPG, SOP WDC-ANA-004\*\*, Procedures for the Analysis of Liquid Samples by Gas Chromatographic Methods, Revision 5, 1 October 2009.
23. U.S. Army DPG, SOP WDC-ANA-031\*\*, Chemical Purity Analysis and Certification, Revision 5, 13 December 2009.
24. U.S. Army DPG, SOP WDC-ANA-012\*\*, Mixing Additives into Chemical Agents, Revision 7, 20 March 2010.
25. ISO 8655, Laboratory Equipment: Piston-Operated Volumetric Apparatus, 10 October 2002 (Corrigenda, 9 December 2008).
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## APPENDIX F. REFERENCES.

30. U.S. Army DPG, SOP DP-0000-M-076\*\*, Chemical Phase of Chemical, Biological, and Radiological Contamination Survivability Testing, Revision 9, 22 June 2009.
31. U.S. Army DPG, SOP WDC-WIN-009\*\*, Work Instruction for the Extraction of Chemical Agent of Simulant from Solid Sorbent Tubes, Revision 3, 13 December 2009.
32. U.S. Army DPG, SOP WDC-ANA-032\*\*, Analysis of Chemical Agents GA, GD, GF, and VX on Solid Sorbent Tubes by Gas Chromatography, Revision 5, 20 March 2010.
33. U.S. Army DPG, SOP WDC-ANA-033\*\*, Analysis of Chemical Agents HD, HN-1, and HN-3 on DAAMS Tubes by Gas Chromatography, Revision 4, 6 April 2009.
34. U.S. Army DPG, SOP WDL-WI-BIO-135\*\*, Assay for Biological Simulants, Revision 5, 4 April 2010.

\*\* The inclusion of SOPs is only to serve as an example of these type procedures that are used at DPG and as a reference for other installations. Many SOPs are specific to a particular installation, facility, or instrument, and may not be applicable between different installations, facilities, or instruments without modifications. It is expected that installations will have their own equivalent SOPs. These equivalent SOPs must be provided to the Test & Evaluation (T&E) community interested in this test method in order to properly understand the data produced, any differences between test method application between installations, and therefore, the ability to compare data produced by different installations. If an installation does not have an equivalent SOP already in place, these or other similar procedures could be used as temporary guides until appropriate SOPs are developed. The most current version of these SOPs can be requested through U.S. Army Test and Evaluation Command (ATEC), or through access to Versatile Information Systems Integrated Online Nationwide (VISION) Digital Library System (VDLS).

For information only (related publications).

- a. Military Standard (MIL-STD)-882D, Standard Practice for System Safety, 10 February 2000.
- b. AR 50-6, Nuclear and Chemical Weapons and Materiel, Chemical Surety, 28 July 2008.
- c. AR 190-59, Military Police, Chemical Agent Security Program, 11 September 2006.

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## CAPAT Cover Sheet

Decontamination Commodity Area Process Action Team  
(CAPAT)

**Test and Evaluation Capabilities and Methodologies Integrated Process Team (TECMIPT) Participants:**









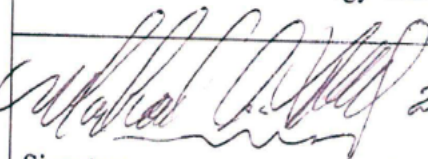
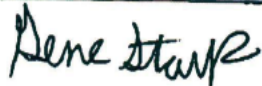


22 June 2012

## APPENDIX G. APPROVAL AUTHORITY.

## CAPAT Signature Sheet

**Test Operations Procedure (TOP) 8-2-111A Chemical, Biological, and Radiological (CBR) Contamination Survivability, Small Items of Equipment**

DECONTAMINATION CAPAT CONCURRENCE SHEET	
Bill Davis Decon CAPAT Chair	Steven Tackett US Army Evaluation Center (AEC)
 3 June 11 Signature Date:	 9/5/11 Signature Date:
JAMES K ECK, Colonel, USAF Vice Commander Air Force Operational Test and Evaluation Center (AFOTEC)	Rob Van Alstine Marine Corps Operational Test and Evaluation Activity (MCOTEA)
 7 JUL 11 Signature Date:	 11/4/11 Signature Date:
LT Shallia Sapatoro Commander Operational Test and Evaluation Force (COMOPTEVFOR)	Jimmy Cornette Deputy Undersecretary of the Army, Test and Evaluation (DUSA TE)
 05 AUG 11 Signature Date:	 29 Aug 11 Signature Date:
Karen Bowen Joint Program Executive Office for Chemical Biological Defense (JPEO-CBD)	Anton Ramage, Lt Col, USAF Joint Requirements Office for Chemical, Biological, Radiological, and Nuclear Defense (JRO-CBRND)
 24 Aug 11 Signature Date:	 28 Aug 11 Signature Date:
Michael Roberts Joint Science and Technology Office (JSTO)	Gene Stark Director T&E, Joint Program Manager Protection (JPM Protection)
 23 Aug 2011 Signature Date:	 25 Aug 11 Signature Date:



APPENDIX G. APPROVAL AUTHORITY.

T&E Capabilities and Methodologies Integrated Process Team (TECMIPT) Chair Endorsement

AMXAA -CD

19 July 2012

MEMORANDUM FOR

Chemical, Biological, Radiological and Nuclear Defense Test and Evaluation Executive, Office of the Deputy Under Secretary of the Army, Taylor Building, Suite 8070, 2530 Crystal Drive, Arlington, VA 22202

SUBJECT: Test Operations Procedure (TOP) 8-2-111A, Chemical, Biological, and Radiological (CBR) Contamination Survivability, Small Items of Equipment

1. The Decontamination Commodity Area Process Action Team (CAPAT) has completed their review of the subject TOP in accordance with the DUSA-TE Instructions to the TECMIPT, the Standards and Development Plan, and the TECMIPT Standard Operating Procedure (SOP). All signatory members of the CAPAT have provided their concurrence to this TOP (enclosed). The CAPAT signature sheets and the ATEC Approval for Publication memorandum are enclosed.
2. Based on the concurrence of the CAPAT, I recommend the CBRND T&E Executive endorse this TOP as a DoD Test and Evaluation (T&E) Standard.

Encl

  
CARL M. EISSNER  
TECMIPT Chair

22 June 2012

## APPENDIX G. APPROVAL AUTHORITY.

### Deputy Under Secretary of the Army Endorsement



**DEPARTMENT OF THE ARMY**  
OFFICE OF THE DEPUTY UNDER SECRETARY OF THE ARMY  
102 ARMY PENTAGON  
WASHINGTON, DC 20310-0102

DUSA TE

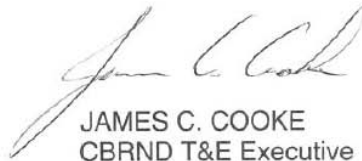
JUL 27 2012

#### MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Endorsement of Test Operating Procedure (TOP) 08-2-111A, Chemical, Biological, and Radiological Contamination Survivability (CBRCS), Small Items of Equipment

1. Reference: Memorandum, DUSA-TE, 19 July 10, subject: Chemical and Biological Defense Program (CBDP) Test and Evaluation (T&E) Standards Development Plan
2. In accordance with the reference, TOP 08-2-111A was coordinated through the T&E Capabilities and Methodologies Integrated Process Team (TECMIPT) development and review process. It received signed concurrences from the members of the Decontamination Capability Area Process Action Team (CAPAT) and was approved by the U.S. Army Test and Evaluation Command (ATEC).
3. In order to support the Life Cycle Management of this TOP, to include future updates and improvements, I request that as this TOP is used, any necessary revisions be provided to the TECMIPT Chair for review. TOPs are references for T&E Strategies (TESs) and T&E Master Plans (TEMPs) and deviations could result in risk of unreliable data.
4. With the enclosed recommendation from the TECMIPT Chair, and approval by DTC, I endorse this TOP as a DoD T&E Standard for CBRCS testing, and encourage its broad use across all test phases. The T&E Standards are for government associated program use and access. They are stored in Army Knowledge Online, and in the TECMIPT share point site. To obtain access to the site, contact the site administrator, [Lynn.coles@us.army.mil](mailto:Lynn.coles@us.army.mil). My point of contact for this action is Megan Holste, [megan.j.holste.ctr@mail.mil](mailto:megan.j.holste.ctr@mail.mil).

Encl

  
JAMES C. COOKE  
CBRND T&E Executive

## APPENDIX G. APPROVAL AUTHORITY.

Approval for Publication, Director, Test Management Directorate (G9), ATEC-HQ

CSTE-TM

25 June 2012

### MEMORANDUM FOR

Commanders, All Test Centers  
Technical Directors, All Test Centers  
Directors, US Army Evaluation Center  
US Army Operational Test Command

SUBJECT: Test Operations Procedure (TOP) 08-2-111A, Chemical, Biological, and Radiological (CBR) Contamination Survivability, Small Items of Equipment, Approved for Publication

1. TOP 08-2-111A, Chemical, Biological, and Radiological (CBR) Contamination Survivability, Small Items of Equipment, has been reviewed by the US Army Test and Evaluation Command (ATEC) Test Centers, the US Army Operational Test Command, and the US Army Evaluation Center. All comments received during the formal coordination period have been adjudicated by the preparing agency. An abstract of the document is as follows:

This TOP provides basic information to facilitate test planning, conducting, and reporting, and to achieve standardized CBR contamination survivability testing of small items of mission-essential (ME) Army materiel. Small items, for example, include personal gear, small arms, radios, optical devices, small electrical generators, and small packages of materiel. This TOP describes typical facilities, equipment, and procedures used to contaminate small items of equipment. This TOP is to be used primarily for the testing of small items of equipment that are decontaminated by the individual Warfighter or by two-person or three-person teams operating portable and handheld decontaminating devices.

2. This document is approved for publication and has been posted to the Reference Library of the ATEC Vision Digital Library System (VDLS). The VDLS website can be accessed at <https://vdl.s.atc.army.mil/>.

3. Comments, suggestions, or questions on this document should be addressed to US Army Test and Evaluation Command (CSTE-TM), 2202 Aberdeen Boulevard-Third Floor, Aberdeen Proving Ground, MD 21005-5001; or e-mailed to [usarmy.apg.atec.mbx.atec-standards@mail.mil](mailto:usarmy.apg.atec.mbx.atec-standards@mail.mil).

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EL.J.1229197289  
MICHAEL J. ZWIEBEL  
Director, Test Management Directorate (G9)

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DN: c=US, o=U.S. Government, ou=DoD,  
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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Range Infrastructure Division (CSTE-TM), U.S. Army Test and Evaluation Command, 2202 Aberdeen Boulevard, Aberdeen Proving Ground, Maryland 21005-5001. Technical information may be obtained from the preparing activity: Commander, U.S. Army Dugway Proving Ground (TEDT-DPW-TT), Dugway, Utah 84022-5000. Additional copies can be requested through the following website: <http://itops.dtc.army.mil/RequestForDocuments.aspx>, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.